Appendix B: Methods, Sampling Instruction Sheets and SOPs

B1 Extractive Acetylene Sampling and Analysis

B1.a. Method TO-3: Method for the Determination of Volatile Organic Compounds in Ambient Air Using Cryogenic Preconcentration Techniques and Gas Chromatography with Flame Ionization and Electron Capture Detection

B1.b. SOP for Analysis of C1-C6+ using Gas Chromatography with Flame Ionization Detection (FID) in Accordance with a Modification of EPA Compendium Method TO-3

B1.c. Lung Sampling Instruction Sheet

B1.d. Canister Sampling Instruction Sheet

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B2.b. Ammonia Sampling Instructions

B3. SOP for Determination of Hydrogen, Carbon Monoxide, Carbon Dioxide, Nitrogen, Methane, and Oxygen using Gas Chromatography with Thermal Conductivity Detection (TCD) in Accordance or Modification of EPA Method 3C or ASTM D 1946

B4. Extractive Hydrogen Fluoride Sampling and Analysis NMAM Method 7903: Acids, Inorganic

B5 Extractive Hydrogen Cyanide Sampling and Analysis

B5.a. NMAM Method 6010: Hydrogen Cyanide

B5.b. Datachem Laboratories, Inc. SOP for NIOSH Method 6010 – Modified

B6. SOP for Analysis of Sulfur Compounds in a Gaseous Matrix by Gas Chromatography with Sulfur Chemiluminescence Detection per ASTM D 5504 and Modified SCAQMD Method 307

B7. Method 1003: Phosphine

B8: Field Screening with GasAlertMicro5

B8.a. SOP for Field Operating Procedures for the GasAlertMicro5® Portable Multi-Gas Detector

B8.b. GasAlertMicro 5 and GasAlertMicro 5 PID User Manual

B9 Field Screening with RKI Eagle Portable Multi-Gas Detector

B9.a. SOP for Field Operating Procedures for the RIK Eagle 2 Portable Multi-Gas Detector

B9.b. RKI Instruments Eagle 2 Operator's Manual

B10. Procedures for Field Measurement of Wind Speed and Direction using Portable/Hand-Held Instruments

B11. Method 2D: Measurement of Gas Volume Flow Rates in Small Pipes and Ducts

B12: Colorimetric Field Screening for Hydrogen Fluoride

B12.a. Sensidyne Gas Detector Tube 156S Hydrogen Fluoride

B12.b. Sensidyne Model AP-20S Gas Detection Pump Instruction Manual

B1 Extractive Acetylene Sampling and Analysis

B1.a. Method TO-3: Method for the Determination of Volatile Organic Compounds in Ambient Air Using Cryogenic Preconcentration Techniques and Gas Chromatography with Flame Ionization and Electron Capture Detection

METHOD FOR THE DETERMINATION OF VOLATILE ORGANIC COMPOUNDS IN AMBIENT AIR USING CRYOGENIC PRECONCENTRATION TECHNIQUES AND GAS CHROMATOGRAPHY WITH FLAME IONIZATION AND ELECTRON CAPTURE DETECTION

1. Scope

1.1 This document describes a method for the determination of highly volatile compounds having boiling points in the range of -10 to 200°C.

1.2 The methodology detailed in this document is currently employed by numerous laboratories (1-4;8-11). Modifications to this methodology should be accompanied by appropriate documentation of the validity and reliability of these changes.

2. Applicable Documents

2.1 ASTM Standards

D1356 Definition of Terms Related to Atmospheric Sampling and Analysis
E 355 Recommended Practice for Gas Chromatography Terms and Relationships

2.2 Other Documents

Ambient Air Studies (1-4).
U. S. EPA Technical Assistance Document (5).

3. Summary of Method

3.1 Ambient air analyses are performed as follows. A collection trap, as illustrated in Figure 1, is submerged in either liquid oxygen or argon. Liquid argon is highly recommended for use because of the safety hazard associated with liquid oxygen. With the sampling valve in the fill position an air sample is then admitted into the trap by a volume measuring apparatus. In the meantime, the column oven is cooled to a sub-ambient temperature (-50°C). Once sample collection is completed, the valve is switched so that the carrier gas sweeps the contents of the trap onto the head of the cooled GC column. Simultaneously, the liquid cryogen is

removed and the trap is heated to assist the sample transfer process. The GC column is temperature programmed and the component peaks eluting from the columns are identified and quantified using flame ionization and/or electron capture detection. Alternate detectors (e.g., photoionization) can be used as appropriate. An automated system incorporating these various operations as well as the data processing function has been described in the literature (8,9).

3.2 Due to the complexity of ambient air samples, high resolution (capillary column) GC techniques are recommended. However, when highly selective detectors (such as the electron capture detector) are employed, packed column technology without cryogenic temperature programming can be effectively utilized in some cases.

4. Significance

4.1 Volatile organic compounds are emitted into the atmosphere from a variety of sources including industrial and commercial facilities, hazardous waste storage facilities, etc. Many of these compounds are toxic, hence knowledge of the levels of such materials in the ambient atmosphere is required in order to determine human health impacts.

4.2 Because these organic species are present at ppb levels or below, some means of sample preconcentration is necessary in order to acquire sufficient material for identification and quantification. The two primary preconcentration techniques are cryogenic collection and the use of solid adsorbents. The method described herein involves the former technique.

5. Definitions

Definitions used in this document and any user prepared SOPs should be consistent with ASTM D1356(6). All abbreviations and symbols are defined within this document at the point of use.

6. Interferences/Limitations

6.1 Compounds having similar GC retention times will interfere in the method. Replacing the flame ionization detector with more selective detection systems will help to minimize these interferences. Chlorinated species, in particular, should be determined using the electron capture detector to avoid interference from volatile hydrocarbons.

6.2 An important limitation of the technique is the condensation of moisture in the collection trap. The possibility of ice plugging the trap and stopping the flow is of concern, and water subsequently transferred to the capillary column may also result in flow stoppage and cause deleterious effects to certain column materials. Use of permaselective Nafion® tubing in-line before the cryogenic trap avoids this problem; however, the material must be used with caution because of possible losses of certain compounds. Another potential problem is contamination from the Nafion® tubing. The user should consult the literature (7-12) for details on the use of permeation-type driers.

7. Apparatus

7.1 Gas chromatograph/Flame Ionization/Electron Capture Detection System - must be capable of subambient temperature programming. A recent publication (8) describes an automated GC system in which the cryogenic sampling and analysis features are combined. This system allows simultaneous flame ionization and electron capture detection.

7.2 Six-port sampling valve - modified to accept a sample collection trap (Figure 1).

7.3 Collection trap - 20 cm x 0.2 cm I.D. stainless steel tubing packed with 60/80 mesh silanized glass beads and sealed with glass wool. For the manual system (Section 9.2) the trap is externally wrapped with 28 gauge (duplex and fiberglass insulated) type "K" thermocouple wire. This wire, beaded at one end, is connected to a powerstat during the heating cycle. A thermocouple is also attached to the trap as shown in Figure 1.

7.4 Powerstat - for heating trap.

7.5 Temperature readout device - for measuring trap temperature during heating cycle.

7.6 Glass dewar flask - for holding cryogen.

7.7 Sample volume measuring apparatus - capable of accurately and precisely measuring a total sample volume up to 500 cc at sampling rates between 10 and 200 cc/minute. See Section 9.

7.8 Stopwatch.

7.9 Dilution container for standards preparation - glass flasks or Teflon (Tedlar) bags, .002 inch film thickness (see Figure 2).

7.10 Liquid microliter syringes - 5-50 μl for injecting liquid standards into dilution container.

7.11 Volumetric flasks - various sizes, 1-10 mL.

7.12 GC column - Hewlett Packard 50 meter methyl silicone cross-linked fused silica column (.3 mm I.D., thick film) or equivalent.

7.13 Mass flow controller - 10-200 mL/minute flow control range.

7.14 Permeation drier - PermaPure® - Model MD-125F, or equivalent. Alternate designs described in the literature (7-12) may also be acceptable.

8. Reagents and Materials

8.1 Glass beads - 60/80 mesh, silanized.

8.2 Glasswool - silanized.

8.3 Helium - zero grade compressed gas, 99.9999%.

8.4 Hydrogen - zero grade compressed gas, 99.9999%.

8.5 Air - zero grade compressed gas.

8.6 Liquid argon (or liquid oxygen).

8.7 Liquid nitrogen.

8.8 SRM 1805 - benzene in nitrogen standard. Available from the National Bureau of Standards. Additional such standards will become available in the future.

8.9 Chemical standards - neat compounds of interest, highest purity available.

9. Sampling and Analysis Apparatus

Two systems are described below which allow collection of an accurately known volume of air (100-1000 mL) onto a cryogenically cooled trap. The first system (Section 9.1) is an automated device described in the literature (8,9). The second system (Section 9.2) is a manual device, also described in the literature(2).

9.1 The automated sampling and analysis system is shown in Figure 3. This system is composed of an automated GC system (Hewlett Packard Model 5880A, Level 4, or equivalent) and a sample collection system (Nutech Model 320-01, or equivalent). The overall system is described in the literature (8).

9.1.1 The electronic console of the sampling unit controls the mechanical operation of the six-port valve and cryogenic trapping components as well as the temperatures in each of the three zones (sample trap, transfer line, and valve).

9.1.2 The valve (six-port air activated, Seiscor Model 8 or equivalent) and transfer line are constantly maintained at 120°C. During sample collection the trap temperature is maintained at -160 $\pm$ 5°C by a flow of liquid nitrogen controlled by a solenoid valve. A cylindrical 250 with heater, held in direct contact with the trap, is used to heat the trap to 120°C in 60 seconds or less during the sample desorption step. The construction of the sample trap is described in Section 7.3.

9.1.3 The sample flow is controlled by a pump/mass flow controller assembly, as shown in Figure 3. A sample flow of 10-100 mL/minute is generally employed, depending on the desired sampling period. A total volume of 100-1000 mL is commonly collected.

9.1.4 In many situations a permaselective drier (e.g., Nafion®) may be required to remove moisture from the sample. Such a device is installed at the sample inlet. Two configurations for such devices are available. The first configuration is the tube and shell type in which the sample flow tube is surrounded by an outer shell through which a countercurrent flow of clean, dry air is maintained. The dry air stream must be free from contaminants and its flow rate should be 3-4 times greater than the sample flow to achieve effective drying. A second configuration (7) involves placing a drying agent, e.g., magnesium carbonate, on the outside of the sample flow tube. This approach eliminates the need for a source of clean air in the field. However, contamination from the drying agent can be a problem.

9.2 The manual sampling consists of the sample volume measuring apparatus shown in Figure 4 connected to the cryogenic trap/GC assembly shown in Figure 1. The operation of this assembly is described below.

9.2.1 Pump-Down Position

The purpose of the pump-down mode of operation is to evacuate the ballast tank in preparation for collecting a sample as illustrated in Figure 4. (While in this position, helium can also be utilized to backflush the sample line, trap, etc. However, this cleaning procedure is not normally needed during most sampling operations). The pump used for evacuating the system should be capable of attaining 200 torr pressure.

9.2.2 Volume Measuring Position

Once the system has been sufficiently evacuated, the 4-way ball valve is switched to prepare for sample collection. The 3-position valve is used to initiate sample flow while the needle valve controls the rate of flow.

9.2.3 Sample Volume Calculation

The volume of air that has passed through the collection trap corresponds to a known change in pressure within the ballast tank (as measure by the Wallace Tiernan gauge). Knowing the volume, pressure change, and temperature of the system, the ideal gas law can be used to calculate the number of moles of air sampled. On a volume basis, this converts to the following equation:

$$V_s = \frac{)P}{760} \times \frac{298}{T_A + 273}$$

where

V_s = Volume sampled at 760 mm Hg pressure and 25°C.
$)P$ = Change in pressure within the ballast tank, mm of Hg.
V = Volume of ballast tank and gauge.
T_A = Temperature of ballast tank, °C.

The internal volume of the ballast tank and gauge can be determined either by H_2O displacement or by injecting calibrated volumes of air into the system using large volume syringes, etc.

10. Sampling and Analysis Procedure - Manual Device

10.1 This procedure assumes the use of the manual sampling system described in Section 9.2.

10.2 Prior to sample collection, the entire assembly should be leak-checked. This task is accomplished by sealing the sampling inlet line, pumping the unit down and placing the unit in the flow measuring mode of operation. An initial reading on the absolute pressure gauge is taken and rechecked after 10 minutes. No apparent change should be detected.

10.3 Preparation for sample collection is carried out by switching the 6-port valve to the "fill" position and connecting the heated sample line to the sample source. Meanwhile the collection trap is heated to 150°C (or other appropriate temperature). The volume measuring apparatus is pumped-down and switched to the flow measuring mode. The 3-position valve is opened and a known volume of sample is then passed through the heated sample line and trap to purge the system.

10.4 After the system purge is completed, the 3-position valve is closed and the corresponding gauge pressure is recorded. The collection trap is then immersed into a dewar of liquid argon (or liquid oxygen) and the 3-position valve is temporarily opened to draw in a known volume of air, i.e. a change in pressure corresponds to a specific volume of air (see Section 9). Liquid nitrogen cannot be used as the cryogen since it will also condense oxygen from the air. Liquid oxygen represents a potential fire hazard and should not be employed unless absolutely necessary.

10.5 After sample collection is completed, the 6-port valve is switched to the inject position, the dewar is removed and the trap is heated to 150°C to transfer the sample components to the head of the GC column which is initially maintained at -50°C. Temperature programming is initiated to elute the compounds of interest.

10.6 A GC integrator (or data system if available) is activated during the injection cycle to provide component identification and quantification.

11. Sampling and Analysis Procedure - Automated Device

11.1 This procedure assumes the use of the automated system shown in Figure 3. The components of this system are discussed in Section 9.1.

11.2 Prior to initial sample collection the entire assembly should be leak-checked. This task is completed by sealing the sample inlet line and noting that the flow indication or the mass flow controller drops to zero (less than 1 mL/minute).

11.3 The sample trap, valve, and transfer line are heated to 120°C and ambient air is drawn through the apparatus (~60mL/minute) for a period of time 5-10 minutes to flush the system, with the sample valve in the inject position. During this time the GC column is maintained at 150°C to condition the column.

11.4 The sample trap is then cooled to -160 ± 5°C using a controlled flow of liquid nitrogen. Once the trap temperature has stabilized, sample flow through the trap is initiated by placing the valve in the inject position and the desired volume of air is collected.

11.5 During the sample collection period the GC column is stabilized at -50°C to allow for immediate injection of the sample after collection.

11.6 At the end of the collection period the valve is immediately placed in the inject position, and the cryogenic trap is rapidly heated to 120°C to desorb the components onto GC column. The GC temperature program and data acquisition are initiated at this time.

11.7 At the desired time the cryogenic trap is cooled to -160°C, the valve is returned to the collect position and the next sample collection is initiated (to coincide with the completion of the GC analysis of the previous sample).

12. Calibration Procedure

Prior to sample analysis, and approximately every 4-6 hours thereafter, a calibration standard must be analyzed, using the identical procedure employed for ambient air samples (either Section 10 or 11). This section describes three alternative approaches for preparing suitable standards.

12.1 Teflon® (or Tedlar®) Bags

12.1.1 The bag (nominal size; 20L) is filled with zero air and leak checked. This can be easily accomplished by placing a moderate weight (text book) on the inflated bag and leaving overnight. No visible change in bag volume indicates a good seal. The bag should also be equipped with a quick-connect fitting for sample withdrawal and an insertion port for liquid injections (Figure 2).

12.1.2 Before preparing a standard mixture, the bag is sequentially filled and evacuated with zero air (5 times). After the 5th filling, a sample blank is obtained using the sampling procedure outlined in Section 10.

12.1.3 In order to prepare a standard mixture, the bag is filled with a known volume of zero air. This flow should be measured via a calibrated mass flow controller or equivalent flow measuring device. A measured aliquot of each analyte of interest is injected into the bag through the insertion port using a microliter syringe. For those compounds with vapor pressures lower than benzene or for strongly adsorbed species, the bag should be heated (60° C oven) during the entire calibration period.

12.1.4 To withdraw a sample for analysis, the sampling line is directly connected to the bag. Quick connect fittings allow this hook-up to be easily accomplished and also minimizes bag contamination from laboratory air. Sample collection is initiated as described.

12.2 Glass Flasks

12.2.1 If a glass flask is employed (Figure 2) the exact volume is determined by weighing the flask before and after filling with deionized water. The flask is dried by heating at 200°C.

12.2.2 To prepare a standard, the dried flask is flushed with zero air until cleaned (i.e., a blank run is made). An appropriate aliquot of

each analyte is injected using the same procedures as described for preparing bag standards.

12.2.3 To withdraw a standard for analysis, the GC sampling line is directly connected to the flask and a sample obtained. However, because the flask is a rigid container, it will not remain at atmospheric pressure after sampling has commenced. In order to prevent room air leakage into the flask, it is recommended that no more than 10% of the initial volume be exhausted during the calibration period (i.e., 200cc if a 2 liter flask is used).

12.3 Pressurized Gas Cylinders

12.3.1 Pressurized gas cylinders containing selected analytes at ppb concentrations in air can be prepared or purchased. A limited number of analytes (e.g., benzene, propane) are available from NBS.

12.3.2 Specialty gas suppliers will prepare custom gas mixtures, and will cross reference the analyte concentrations to an NBS standard for an additional charge. In general, the user should purchase such custom mixtures, ratherthan attempting to prepare them because of the special high pressure filling apparatus required. However, the concentrations should be checked, either by the supplier or the user using NBS reference materials.

12.3.3 Generally, aluminum cylinders are suitable since most analytes of potential interest in this method have been shown to be stable for at least several months in such cylinders. Regulators constructed of stainless steel and Teflon® (no silicon or neoprene rubber).

12.3.4 Before use the tank regulator should be flushed by alternately pressuring with the tank mixture, closing the tank valve, and venting the regulator contents to the atmosphere several times.

12.3.5 For calibration, a continuous flow of the gas mixture should be maintained through a glass or Teflon® manifold from which the calibration

standard is drawn. To generate various calibration concentrations, the pressurized gas mixture can be diluted, as desired, with zero grade air using a dynamic dilution system (e.g., CSI Model 1700).

13. Calibration Strategy

13.1 Vapor phase standards can be prepared with either neat liquids or diluted liquid mixtures depending upon the concentration levels desired. It is recommended that benzene also be included in this preparation scheme so that flame ionization detector response factors, relative to benzene, can be determined for the other compounds. The benzene concentration generated in this fashion should be cross-checked with an NBS (e.g., SRM 1805) for accuracy determinations.

13.2 Under normal conditions, weekly multipoint calibrations should be conducted. Each multipoint calibration should include a blank run and four concentration levels for the target species. The generated concentrations should bracket the expected concentration of ambient air samples.

13.3 A plot of nanograms injected versus area using a linear least squares fit of the calibration data will yield the following equation:

$$Y = A + BX$$

where

Y = quantity of component, nanograms
A = intercept
B = slope (response factor)

If substantial nonlinearity is present in the calibration curve a quadratic fit of the data can be used:

$$Y = A + BX + CX^2$$

where

C = constant

Alternatively, a stepwise multilevel calibration scheme may be used if more convenient for the data system in use.

14. Performance Criteria and Quality Assurance

This section summarizes the quality assurance (QA) measures and provides guidance concerning performance criteria which should be achieved within each laboratory.

14.1 Standard Operating Procedures (SOPs)

14.1.1 Each user should generate SOPs describing the following activities as accomplished in their laboratories:

1) assembly, calibration and operation of the sampling system.
2) preparation and handling of calibration standards.
3) assembly, calibration and operation of the GC/FID system and
4) all aspects of data recording and processing.

14.1.2 SOPs should provide specific stepwise instructions and should be readily available to, and understood by, the laboratory personnel conducting the work.

14.2 Method Sensitivity, Precision and Accuracy

14.2.1 System sensitivity (detection limit) for each component is calculated from the data obtained for calibration standards. The detection limit is defined as

$$DL = A + 3.3S$$

where

DL = calculated detection limit in nanograms injected.
A = intercept calculated in Section 13.
S = standard deviation of replicate determination of the lowest level standard (at least three determinations are required).

For many compounds detection limits of 1 to 5 nanograms are found using the flame ionization detection. Lower detection limits can be obtained for chlorinated hydrocarbons using the electron capture detector.

14.2.2 A precision of ± 5% (relative standard deviation) can be readily achieved at concentrations 10 times the detection limit. Typical performance data are included in Table 1.

14.2.3 Method accuracy is estimated to be within ± 10%, based on National Bureau of Standard calibrated mixtures.

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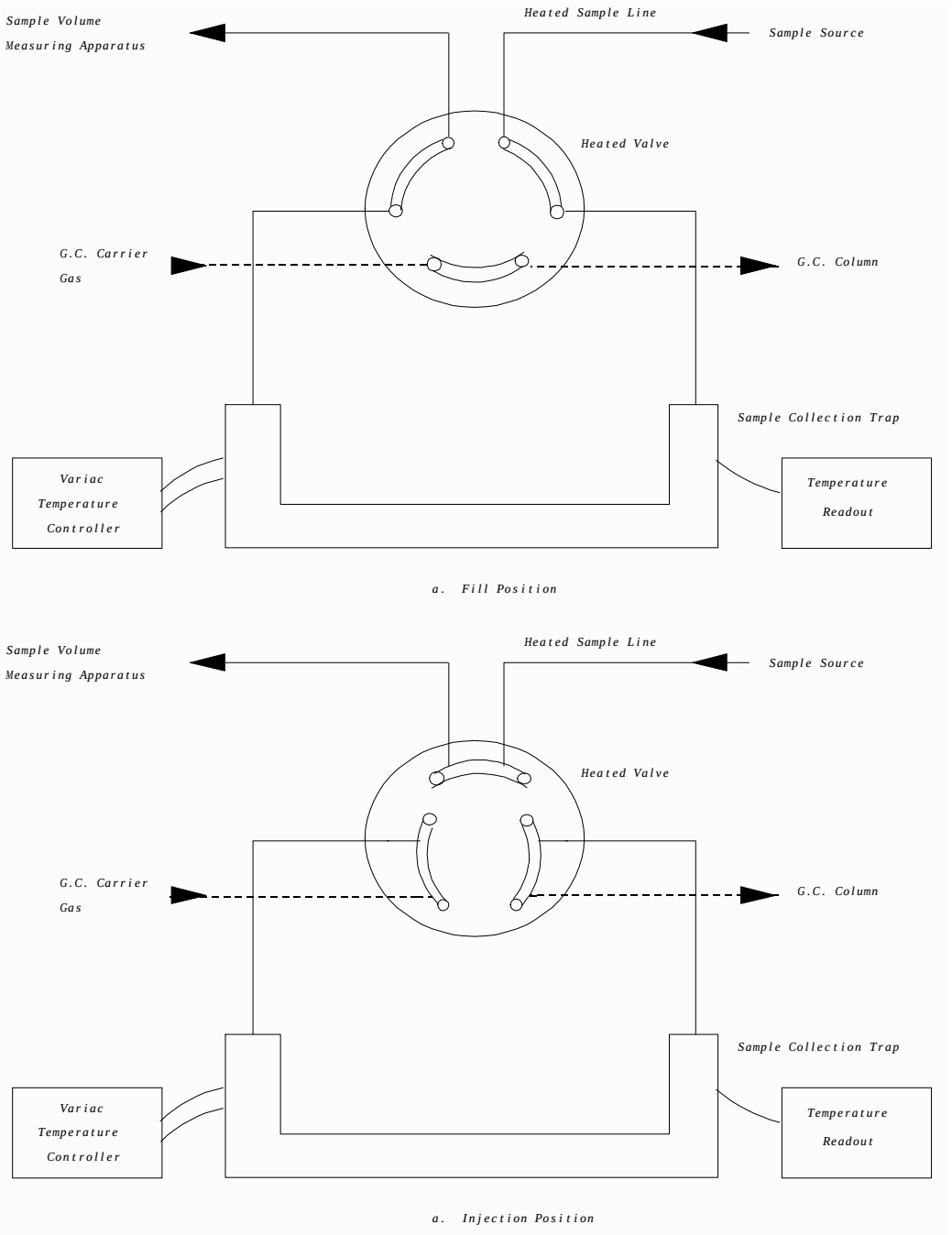


Figure 1. Schematic of Six-Port Valve Used for Sample Collection.

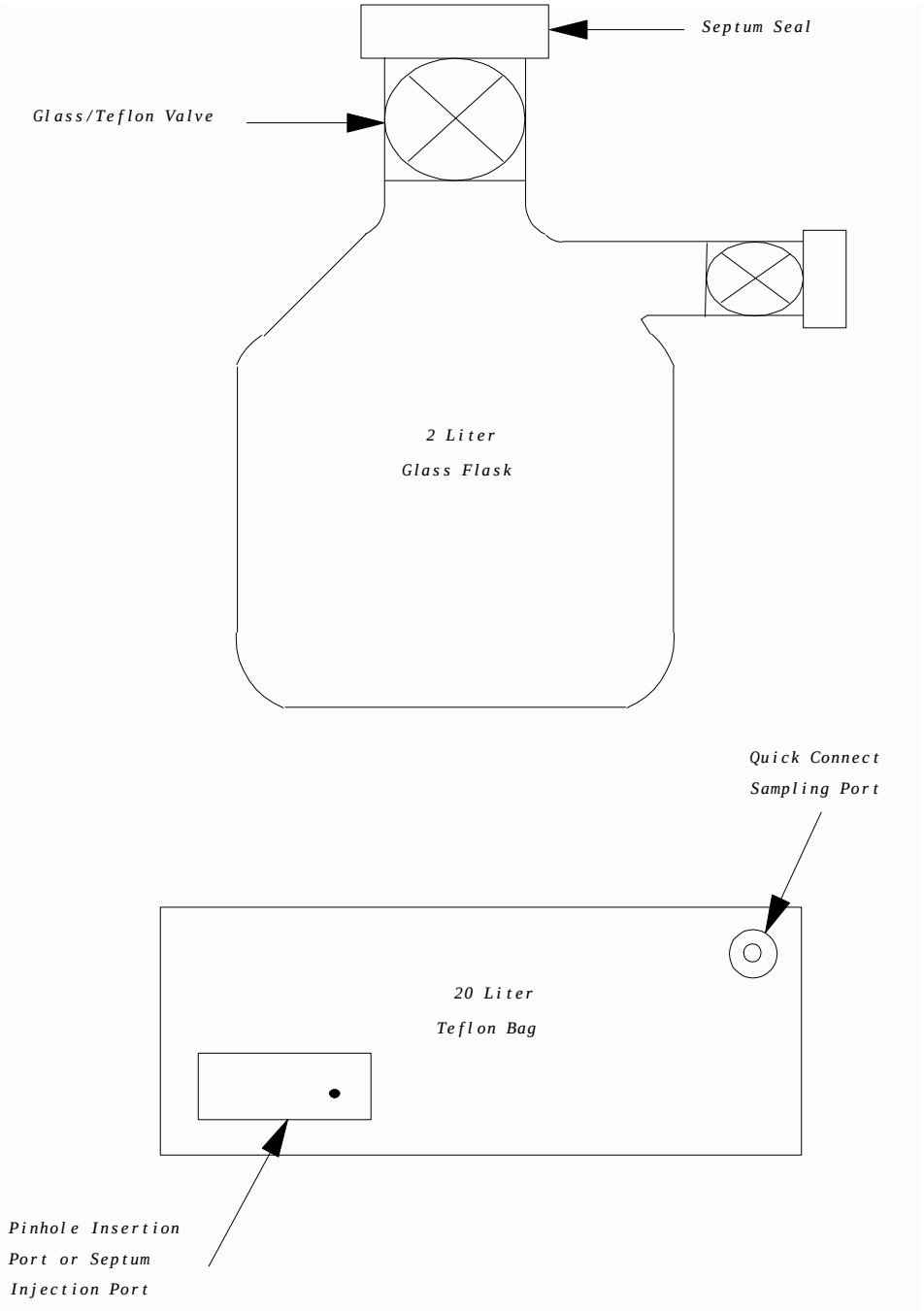


Figure 2. Dilution Containers for Standard Mixtures

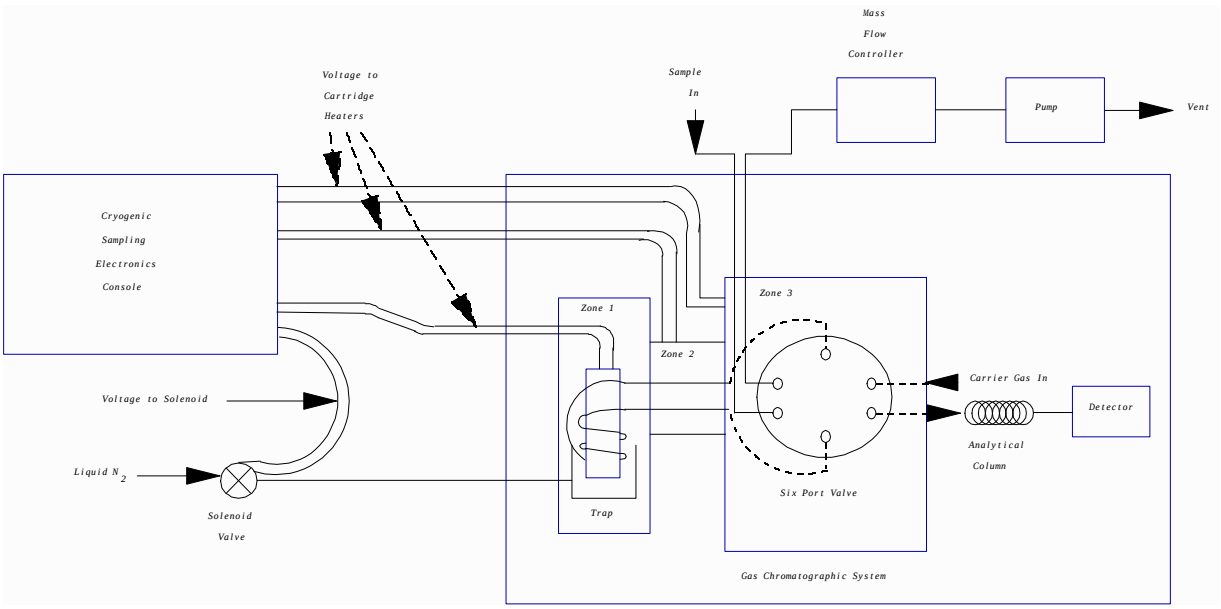


Figure 3. Automated Sampling and Analysis System for Cryogenic Trapping

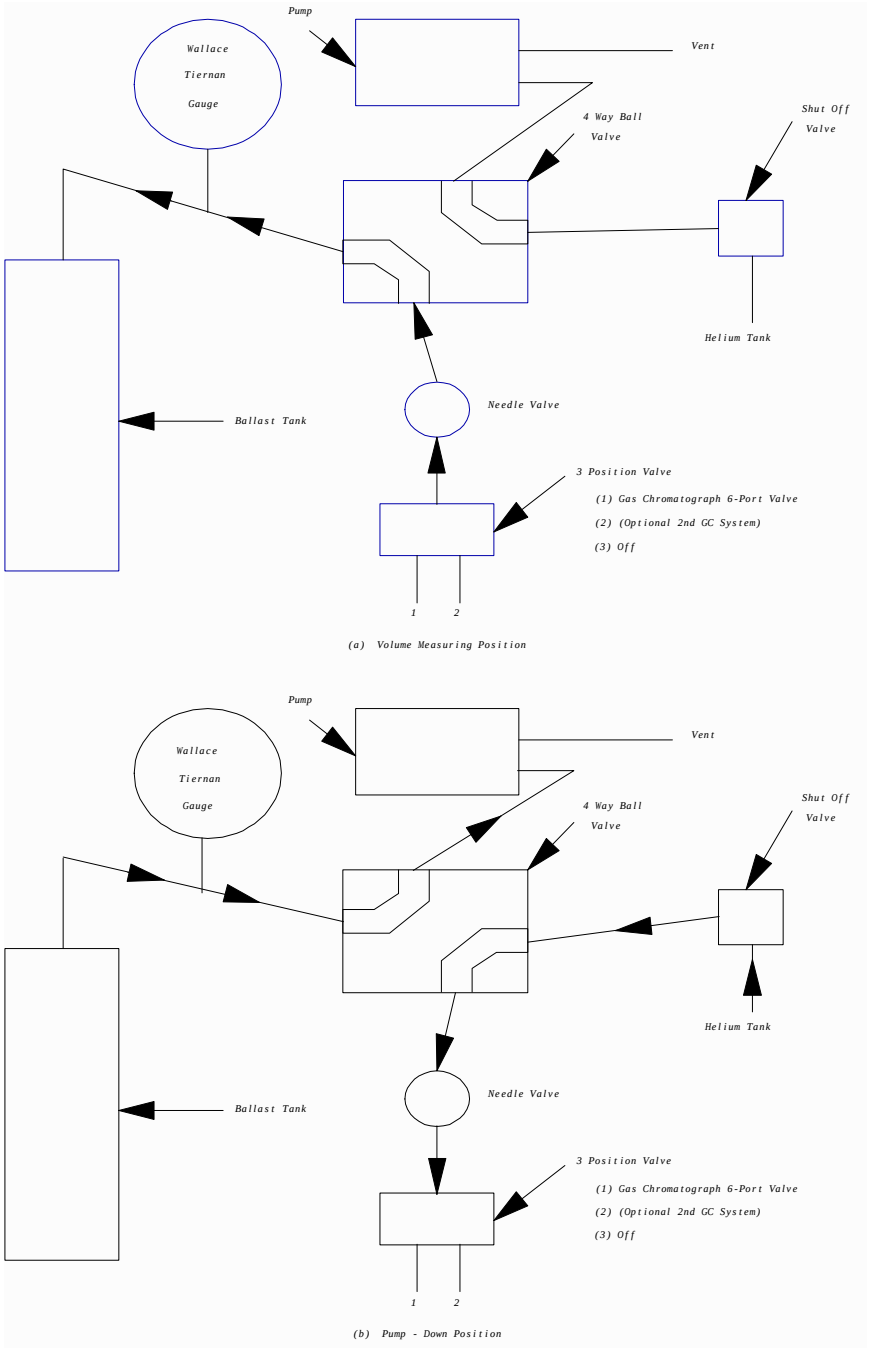


Figure 4. Sample Volume Measuring Apparatus

TABLE 1. VOLATILE ORGANIC COMPOUNDS FOR WHICH THE CRYOGENIC SAMPLING METHOD HAS BEEN EVALUATED[a]

Compound	Retention Time, Minutes[b]	Test 1 (4 runs, 200cc samples) Mean (ppb)	%RSD	Test 2 (8 runs, 200-cc samples) Mean (ppb)	%RSD
Vinylidene Chloride	9.26	144	4.4	6.1	3.9
Chloroform	12.16	84	3.8	3.5	5.8
1,2-Dichloroethane	12.80	44	3.7	1.9	5.1
Methylchloroform	13.00	63	4.5	2.7	4.9
Benzene	13.41	93	4.0	3.9	5.1
Trichloroethylene	14.48	84	3.7	3.5	4.1
Tetrachloroethylene	17.37	69	3.7	2.9	4.3
Chlorobenzene	18.09	46	3.3	1.9	3.2

[a] Recovery efficiencies were 100 ± 5% as determined by comparing direct sample loop (5cc) injections with cryogenic collection techniques (using test 1 data). Data from reference 10.

[b] GC conditions as follows:

Column - Hewlett Packard, crosslinked methyl silicone, 0.32 m ID x 50 m long, thick film, fused silica.

Temperature Program - 50°C for 2 minutes, then increased at 8°C/minute to 150°C.

B1.b. SOP for Analysis of C1-C6+ using Gas Chromatography with Flame Ionization Detection (FID) in Accordance with a Modification of EPA Compendium Method TO-3

STANDARD OPERATING PROCEDURE

for

Analysis of C_1-C_6+ using Gas Chromatography with Flame Ionization Detection (FID) in Accordance with a Modification of EPA Compendium Method TO-3

SOP Code: VOA-TO3C1C6

Revision: 9

Effective Date: 9-5-11

Approved by:

Wade Henton – VOA GC Team Leader	8/25/11 Date
Chaney Humphrey – Quality Assurance Program Manager	8/25/11 Date
Kelly Horiuchi – Laboratory Manager	08/27/11 Date

2655 Park Center Drive, Suite A
Simi Valley, CA 93065

Annual review of this SOP has been performed and the SOP still reflects current practice.

Initials: _____ Date: _____
Initials: _____ Date: _____
Initials: _____ Date: _____

DOCUMENT CONTROL

NUMBER: Non-Controlled

Initials: _____ Date: _____

Standard Operating Procedure for the Analysis of C_1-C_6+ using Gas Chromatography with Flame Ionization Detection (FID) in Accordance with a Modification of EPA Compendium Method TO-3

1.0 SCOPE AND APPLICATION

This gas chromatographic method is used in the analysis of methane, ethane, ethene, propane, propene, n-butane, n-pentane, n-hexane and hydrocarbon ranges from C2 to greater than C6 by a modification of EPA Compendium Method TO-3. This method applies to but is not limited to the following sample matrices: ambient air, source emissions, landfill gases, digester gases, and vehicular exhaust. The range of this method for quantifying target analyte gases, depending on the concentration of the samples, is approximately 0.5ppm to percent values. The upper limit may be extended by diluting the sample with an inert gas or by using a smaller injection volume. The number of samples, which may be analyzed in one eight hour day, is approximately twenty. The reporting limits for these analytes are listed in Attachment D of this standard operating procedure. The method reporting limit for a compound is defined as the minimum reliably quantifiable concentration of that compound.

2.0 METHOD SUMMARY

Samples are collected as vapor in Tedlar bags, Summa or specially prepared canisters and delivered to the laboratory for analysis. An aliquot is drawn from the sampling container using a gas tight syringe and injected onto a packed chromatographic column where the analytes are separated and measured using a flame ionization detector (FID). Analytes and hydrocarbon ranges are identified and quantified based on their retention time, which is compared with that of a known standard under identical conditions.

3.0 DEFINITIONS

3.1 Relative Standard Deviation (RSD)

The RSD is the coefficient of variation (CV; ratio of the standard deviation to the mean) multiplied by 100 to convert the CV to a percentage of the mean.

3.2 Analytical Sequence

The analytical sequence describes exactly how the field and QC samples in an analytical batch are to be analyzed.

3.3 Field Sample

A sample collected and delivered to the laboratory for analysis.

3.4 Batch QC

Batch QC refers to the QC samples that are analyzed in an analytical batch of field samples and includes the Method Blank (MB), Laboratory Control Sample (LCS) and Laboratory Duplicate (LD), etc.

3.5 Calibration Standard (Initial Calibration – ICAL)

A certified calibration standard is a purchased from an outside vendor. A calibration standard is analyzed at varying concentrations and used to calibrate the response of the measurement system with respect to analyte concentration.

3.6 Initial Calibration Verification (ICV) Standard

An initial calibration verification standard (ICV) is a second source certified standard that is purchased from an outside vendor and is analyzed after the measurement system is calibrated, but prior to sample analysis in order to verify the calibration of the measurement system.

3.7 Continuing Calibration Verification (CCV) Standard

A continuing calibration verification standard (CCV) is a midrange calibration standard that is analyzed periodically to verify the continuing calibration of the measurement system.

3.8 Method Blank (MB)

The method blank (MB) for this method is ultra pure nitrogen that is analyzed to verify the zero point of the analytical system and to verify freedom from carryover.

3.9 Laboratory Control Sample (LCS)

For the purposes of this document, a laboratory control sample (LCS) shall be a calibration standard of known concentration. The percent recovery of the analyte(s) in the LCS is used to assess method performance.

3.10 Laboratory Duplicate

Aliquots of a sample taken from the same container under laboratory conditions which are processed and analyzed independently.

3.11 Precision

Precision of a method is how close results are to one another, and is usually expressed by measures such as standard deviation, which describe the spread of results.

3.12 Bias

The bias of a method is an expression of how close the mean of a set of results (produced by the method) is to the true value.

3.13 Manual Integration

This term applies to a data file in which setpoints have been changed and reintegration has occurred under the changed setpoints; baselines have been adjusted; peak integration start and stop "ticks" have been changed; peak area, or peak height, are changed after the time of data collection and data file generation.

3.14 Limit of Detection (LOD)

The smallest amount or concentration of a substance that must be present in a sample in order to be detected at a high level of confidence (99%). At the LOD, the false negative rate (Type II error) is 1%. (DoD Clarification). For consistency purposes, the LOD may be referred to as the MDL once it is reported; however, full verification will be on file in the laboratory per the procedures detailed in this document.

3.15 Limit of Quantitation (LOQ)

The lowest concentration that produces a quantitative result within specified limits of precision and bias. For DoD projects, the LOQ shall be set at or above the concentration of the lowest initial calibration standard. (DoD Clarification). For consistency purposes and since the LOQ and MRL are equivalent with regards to laboratory procedure, the LOQ will be referred to as the MRL in this document and once it is reported. Full verification will be on file in the laboratory per the procedures detailed in the document.

3.16 Detection Limit (DL) / Method Detection Limit (MDL)

The smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration at the 99% level of confidence. At the DL, the false positive rate (Type 1 error) is 1%. (DoD Clarification). For consistency purposes, the DL may be referred to as MDL. Also, as far as reporting is concerned the MDL will be raised up (where necessary) to the verified LOD per the procedures defined in this document and reported accordingly.

4.0 INTERFERENCES

4.1 Contamination

4.1.1 Column Conditioning Conditioning of the chromatographic column is required prior to use of the system. The column should be conditioned with a continuous flow of chromatographic grade helium and temperature programmed from 35°C to 200°C at a rate of five degrees per minute. The column should be held at 200°C for at least four hours.

4.1.2 Contamination in the Sample Care must be taken to prevent ambient air intrusion into the sample container during canister pressurization and laboratory analysis. When using adapters and fittings the dead volume must be evacuated and replaced with the sample gas prior to sampling from the container. The sampling syringe shall then be flushed with the sample gas to remove residual ambient air. An aliquot greater than is needed is drawn, and the syringe plunger is adjusted to the appropriate volume *immediately* before injecting.

4.1.3 Carrier Gas Contamination To prevent system contamination, UHP/ZERO grade helium (99.999% purity) is used as the carrier gas. Also, a purifier and an oxygen trap are incorporated into the analytical system as additional insurance against possible contamination.

4.1.4 Injection Port Maintenance When performing injection port maintenance and when the injection port septa is replaced a back end chromatographic bleed can be observed. When this happens sample analysis for the heavier hydrocarbons (C5-C6) cannot be performed. To "clean" the system, raise the injection port temperature to 180°C and the oven temperature to 270°C , let bake overnight for 1 to 3 days. During the day instrument blanks should be analyzed.

5.0 SAFETY

Each compound, mixture of compounds and standards, as well as samples, should be treated as a potential health hazard. Exposure to these chemicals should be reduced to the lowest level possible through the use of gloves (to minimize absorption through the skin) and hoods (to minimize inhalation). Refer to the laboratory's Environmental Health and Safety Manual as it makes reference to the safe handling of chemicals, MSDS location, as well as the ***SOP for Waste Disposal*** for the proper disposal of chemicals and samples.

5.1 Material Safety Data Sheets (MSDS)

Material safety data sheets (MSDS) are available and should be reviewed as part of employee training.

5.2 Protective Clothing

Personal protective clothing (safety glasses and gloves) should be used when preparing standards, handling standards in neat form or performing maintenance on pressurized systems.

5.3 Pressurized Gases

The use of pressurized gases is required for this procedure. Care should be taken when moving cylinders. All gas cylinders must be secured to a wall or an immovable counter with a chain or a cylinder clamp at all times. The regulator should not remain on size "D" cylinders when not in use. Sources of flammable gases (i.e. pressurized hydrogen) should be clearly labeled.

5.4 Syringes

Care should be taken to avoid personal injury as a result of improper handling techniques.

6.0 SAMPLE COLLECTION, CONTAINERS, PRESERVATION, AND STORAGE

The samples are collected and delivered to the laboratory for analysis in either Tedlar bags or specially prepared canisters. Samples collected in bags must be analyzed within 72 hours after sample collection unless otherwise specified by the client. Samples delivered in cleaned,

evacuated summa or other specially prepared canisters do not have specified holding times for atmospheric gases but should be analyzed within 30 days from the date of collection.

7.0 APPARATUS AND EQUIPMENT

7.1 Gas Chromatograph

GC7, GC8

HP 5890A, Series II or equivalent (i.e., HP 6890) equipped with a flame ionization detector, and having a temperature programmable oven with sub-ambient cooling capability. The column shall be 60m, 0.53mm ID RT_x-1 or equivalent with a 5µm film thickness.

GC10

Hewlett-Packard Model 5890 Series II Gas Chromatograph or equivalent equipped with a flame ionization detector (FID). The column shall be J&W MXT-QPlot, 053mm x 30m or equivalent.

7.2 Regulators

Regulators are used on the gas cylinders supplying the GC and for preparing cylinder standards.

7.3 Data System

A data system with the ability to collect data from the GC detector, integrate the peaks and perform the appropriate quantification calculations shall be used. This laboratory currently uses HP Chemstation/Enviroquant GC software.

7.4 Syringes

Gas tight syringes of the following volumes: 10mL, 2.5mL, 1.0mL, 0.5mL and 0.25mL.

7.5 Tedlar Bags/Glass Bombs

Glass "bombs" of volumes 125 or 250mL and new Tedlar bags are used for diluting very concentrated samples, which fall outside of the initial calibration range.

8.0 STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

All samples and standards must be stored separately. The concentration, preparation and expiration date as well as analyst's initials must be identified on the standard label. Each standard must also be uniquely identified with a laboratory ID number.

All certificates shall be maintained (turned in to the quality assurance department) and noted with the standard identification number, date received and initials of the receiving analyst. For additional information on these and other requirements, refer to the ***SOP for Handling Consumable Materials***.

8.1 Carrier and Calibration Standard Balance Gas

8.1.1 Helium UHP/ZERO (99.999%) or higher in purity
8.1.2 Nitrogen UHP/ZERO (99.999%) or higher in purity
8.1.3 Hydrogen 99.999%, fuel source for FID
8.1.4 Zero Air Ultra

8.2 Standards

8.2.1 Purchased Standards

These standards must be stored in accordance with the requirements described in the ***SOP for Handling Consumable Materials***. These standards may be stored for a period of 2 years or as recommended by the manufacturer.

8.2.1.1 Scott Specialty Gas cylinders (or similar)

Compound	**Concentration**			
Methane	1%	1000ppm	100ppm	15ppm
Ethane	1%	1000ppm	100ppm	15ppm
Propane	1%	1000ppm	100ppm	15ppm
n-Butane	1%	1000ppm	100ppm	15ppm
n-Pentane	1%	1000ppm	100ppm	15ppm
n-Hexane	NA	1000ppm	100ppm	15ppm
Balance Gas: Nitrogen				

Note: Specific concentrations of these standards may change with each purchase.

8.2.1.2 Scotty Mix 48 or Equivalent

Compound	Methane	Ethylene	Ethane	Propane	Acetylene	Propylene	Propyne	n-Butane	Balance Gas:
Approximate Concentration (ppm by vol.)	15	15	15	15	15	15	15	15	Nitrogen

Note: These stock standards contain compounds that are not reported. The actual concentrations of these standards may change with each purchase.

8.2.1.3 Neat Standards

Compound	**Approximate Concentration (ppm)**
Carbon dioxide	990,000
Ethylene(Ethene)	990,000
Methane	990,000
Propylene	990,000
Propane	990,000
Ethane	990,000

Note: The specific concentrations of these standards may change with each purchase. If utilizing an ultra high purity (UHP) gas cylinder, the certificate must be on file and it shall meet all of the minimum UHP requirements with respect to impurity content.

8.2.1.4 Matheson Specialty Gas (or similar)

Compound	Concentration
Methane	1000ppm
Ethane	1000ppm
Propane	1000ppm
n-Butane	1000ppm
n-Pentane	1000ppm
n-Hexane	1000ppm
Balance Gas: Nitrogen	

Note: Two different lots or manufacturers of this type of standard are purchased for use as the primary and the secondary source standards. The specific concentrations of these standards may change with each purchase.

8.2.1.5 Scott Specialty Gas (or similar)

Compound	Concentration
Methane	40000ppm

8.2.1.6 Scott Specialty Gas (or similar)

Compound	Concentration
Methane	99.0+%

8.2.1.7 Aldrich Chemical Company (or similar)

Compound	Concentration
n-Hexane	99.0+%

8.3 Calibration Standards

8.3.1 Initial Calibration (ICAL) and Continuing Calibration Verification (CCV) Standards Working standards shall be prepared from higher concentration stock standards purchased from commercial vendors (see Section 8.2).

8.3.1.1 Procedure - Aliquots of the stock standards are spiked into a cleaned and evacuated 6.0 liter summa canister (***SOP for Cleaning and Certification of Summa Canisters and Other Specially Prepared Canisters***) by using gastight syringes. The canister is then balanced with helium or nitrogen

per the ***SOP for Evaluation and Pressurization of Specially Prepared Canisters*.**

Step 1: Determine the actual pressurized volume of the 6L canister by the use of the following equation.

PV = PDF(V) **(Equation 1)**

Where:

PV	Pressurized canister volume (L)
PDF	Pressure Dilution Factor, where PDF = $\frac{p_{atm} + p_f}{p_{atm} - p_i}$
P_f	Final Canister Pressure
P_i	Initial Canister Pressure
V	Volume of canister @ 1atm
p_{atm}	Pressure @ 1atm = 14.7

Example:

$$\frac{14.7+65}{14.7-0}(6L) = 32.53\text{L}$$

Step 2: Determine the amount required to achieve the desired concentration(s) by utilizing the following equation.

$$S = \frac{(C_1)(PV)}{(C_2)} x \frac{1000mL}{1L} \quad \textbf{(Equation 2)}$$

Where:

S	Spike amount required in order to obtain the desired concentration (mL)
C_1	Desired concentration (ppm)
C_2	Concentration of source (ppm)
PV	Pressurized volume of canister determined in Step 1 (L)

The concentrations listed in this table are based on the purchased neat standards listed in Section 8.2.1.3 and may change with each purchased standard. However, the nominal concentrations should remain close to that listed below.

Compound	Source Conc. (ppm)	Introduce (mL)	Nominal Conc. (ppm)
Carbon dioxide	998,000	326	10,000
Methane	990,000	82.15	2500
Ethene	10,000	1626.5	500
Ethane	990,000	16.43	500
Propane	990,000	16.43	500
Propene	10,000	1626.5	500

Note: The exact volumes injected, to make a working standard, must be used to determine the final concentration of the standard.

In order to achieve all of the desired concentrations for each analyte in the ICAL or CCV, additional standard dilutions may be required. These dilutions may be prepared in glass dilution bombs (i.e., 125mL) or Tedlar bags and are achieved by following step 3 below.

Step 3: Determine the correct injection amount based on the desired final concentration for a target analyte by utilizing the following equation.

Using $C_1V_1 = C_2V_2$

Where: C_1 = Initial concentration (i.e., 2500ppm methane stock solution)
C_2 = Final desired concentration (i.e., 2.5ppm)
V_2 = Final volume (125mL or 125000uL – glass dilution bomb)
V_1 = Solve for V_1 (uL)

Step 4: To perform the ICAL or to analyze a CCV, determine the correct instrument injection volume for an analyte by utilizing the following equation.

$$I = \frac{C_2}{C_1}$$

where:

I required injection (mL)
C_1 Source (initial) concentration (ppm)
C_2 Desired concentration (ppm)

8.3.2 Initial Calibration Verification (ICV) Standard This standard must be from a second source (manufacturer or lot) and used as a verification of the initial calibration. Prepare the ICV as specified in Section 8.3.1.

8.3.3 Laboratory Control Sample Spike The same standard as detailed in Section 8.3.2 may be used to spike the LCS and LCSD.

8.4 Storage and Expiration Dates

8.4.1 Stock Standards

The stock standards are purchased in gas cylinders and are stored at ambient temperature. Expiration dates are either assigned by the manufacturer or by an analyst for two years from receipt.

8.4.2 Calibration Standards (ICAL, ICV and CCV)

Store each standard at an ambient temperature for a period detailed below, depending on the container.

Summa or Other Specially Prepared Canister = Two years
Tedlar Bags and Glass dilution bombs = Three days

For additional information please see the ***SOP for Handling Consumable Materials.***

9.0 PREVENTIVE MAINTENANCE

A maintenance log shall be kept documenting maintenance performed on each analytical system and the instrument maintenance log must be kept current. The serial numbers of each instrument shall be recorded in the front of the logbook. An entry shall be made in the appropriate log every time maintenance is performed (no matter the extent). The extent of the maintenance is not important, however, it is important that a notation be included for each maintenance activity such as changing a column, tuning the instrument, or cleaning the source. The entry in the log must include:

(a) The date of maintenance
(b) Who did the maintenance
(c) Description of the maintenance
(d) Proof that the maintenance activity was successful

A notation of a successful continuing calibration or initial calibration shall serve as proof that the maintenance is complete and the instrument is in working order.

9.1 Carrier Gas Purifier

If in-line purifiers or scrubbers are in place, these purifiers must be changed as recommended by the supplier.

9.2 GC System

9.2.1 Column Performance should be monitored by observing peak shapes and column bleed. Over time, the column may exhibit a poor overall performance, as

contaminated sample matrices are analyzed. The length of time for this to occur depends on the samples analyzed. When a noticeable decrease in column performance is evident and other maintenance options do not result in improvement, the column should be replaced. Whenever GC maintenance is performed, care should be taken to minimize the introduction of air or oxygen into the column.

Clipping off a small portion of the head of the column often enhances chromatographic performance. When cutting off any portion of the column, make sure the cut is straight and "clean" (uniform, without fragmentation) by using the proper column-cutting tool. When removing any major portion of the column, which will affect the retention times and elution characteristics, a change in instrument conditions may be required to facilitate nominal analytical activity.

Decreasing performance can also be due to ineffective column ferrules, which should be replaced when a tight seal around the column is no longer possible. This can be detected with the use of a leak detector.

9.2.2 Injection Port Injection port maintenance includes changing the injection port liner and column ferrule as needed. Liners should be changed when recent sample analyses predict a problem in chromatographic performance.

9.2.3 Injector Septa Septa should be changed monthly or whenever there is a noticeable change in peak definition. For best results with air analyses, two septa are placed into the injector in order to eliminate loss during manual injections.

9.2.4 Detector Clean FID jet as needed.

10.0 RESPONSIBILITIES

It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review and reporting per the corresponding standard operating procedures. Personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP must perform analysis and interpretation of the results. This demonstration shall be in accordance with the training program of the laboratory described in Section 19.0 and the ***SOP for Documentation of Training***. The department supervisor/manager or designee shall perform final review and sign-off of the data.

11.0 PROCEDURE

Sufficient raw data records must be retained of the analysis, instrument calibrations and method detection limit studies including: analysis/calibration date and time, test method, instrument, sample identification, each analyte name, analyst's initials, concentration and response, and standards used for the analysis and calibrations, any manual calculations including sample dilutions and manual integrations. Make sure that all information entered and reported on the quantitation report and instrument run log is complete and accurate. If manual integration is necessary the guidelines described in Section 11.10 shall be followed.

11.1 Sample Preparation and Analysis Observations / Case Narrative Summary Form

This form, which is included in the ***SOP for Laboratory Storage, Analysis, and Tracking***, must be generated when there are any specific sample composition information, sample preparation, analysis issues and/or observations. In addition, during the analysis, specific identification information or problems, interferences, calibration issues, flags, and additional/expanded explanation of flags should be added to the form. This form may be modified as long as the sections and basic concepts are reserved.

This form is necessary as a means for documentation. This form, among other information, will be reviewed when compiling the final report and case narrative. All information regarding the job shall remain in the file, in order that sufficient documentation is available to recreate the job from sample receipt through preparation, analysis, data reduction, and reporting.

11.2 Analytical Sequence and Data System Setup

11.2.1 Data System Load the appropriate acquisition method file for the correct GC temperature program (ex. J:\GC7\Method\TO3.m). Load the appropriate analytical sequence (ex. J:\GC7\Sequence\TO3.s). Enter the analytical sequence information in the table window, including standard name, sample name and injection volume. Load the appropriate quantitation method file (example - J:\GC7\Method\current ICAL method). Run the sequence and inject the standards and samples per the guidelines in Section 11.2.2.

11.2.2 Analytical Sequence The analytical batch must be completed for the analysis of ≤ 20 field samples. Laboratory duplicates (LD), duplicate field samples and sample dilutions are considered samples. Batch QC samples may be analyzed anywhere in the analytical sequence, with the exception of the method blank which must be analyzed prior to sample analysis in order to demonstrate a contamination free system.

Analytical Sequence Guideline[1]

Sample Description(w/ICAL)	***Sample Description***
Calibration Stds.[2]	CCV[3]
ICV[4]	MB[5]
MB[5]	LCS[6]
LCS[6]	Samples 1-10
Samples 1-10	CCV[3]
CCV[3]	Samples 11-19
Samples 11-19	LD[7]
LD[7]	CCV[3]
CCV[3]	

[1]The batch QC may be analyzed in an order other than the one listed in this document; the analytical sequence specified below is a guideline.

[2]The initial calibration must be generated in accordance with the guidelines detailed in Section 11.4 of this document.
[3]In cases, where the ICAL is not performed the analytical sequence must begin with the analysis of a CCV standard. In addition, a CCV must be analyzed every ten samples and the analytical sequence shall end with an acceptable CCV.
[4]Every ICAL must be followed by a second source standard (ICV) which contains all of the target analytes.
[5]The method blank must be analyzed prior to any samples within the sequence.
[6]Every analytical sequence must include a laboratory control sample. A LCS shall be analyzed at a rate of one per twenty samples or fewer for each analyte.
[7]A laboratory duplicate must be analyzed at a frequency of 1 in 20 or fewer samples.

11.3 GC Configuration

11.3.1 Temperature Program The carrier gas flow rate and sub-ambient GC oven temperature programming must be set to completely elute all of the target analytes. The temperature program ramps up to a high temperature, not exceeding the maximum temperature rating of the column in use, and holds there to allow all heavier hydrocarbons to elute, in order to prevent carryover to the next injection.

The settings and system parameters are as follows:

Parameters	**HP 6890 – GC7**	**HP 5890 – GC8**	**HP 5890 – GC10**
Sample Inlet	GC	GC	GC
Injection Source	Manual	Manual	Manual
Injection Location	Back	Front	Front
Run Time	14.27	16.00	~10.0min
OVEN			
Initial Temp.	-20°C	-30°C	55°C
Max. Temp.	325°C	325°C	250°C
Initial Time	1.0min	1.0min	2.0min
Equilibration Time	0.0min	0.0min	0.0min
RAMP			
Rate	22°C /min	20°C /min	20°C /min
Final Temp.	250°C	250°C	250°C
Final Time	3.0min	1.0min	0.5min
INJECTOR			
Mode	Packed Column	Packed Column	Packed Column
Temp.	150°C	150°C	100°C
Pressure	11psi at -20°C oven temp	24psi at -30°C oven temp	20psi at 55°C oven temp

COLUMN			
Model No.	RTx-1	RTx-1	J&W MXT-QPlot
Max. Temp.	325°C	325°C	250°C
Nominal Length	60m	60m	30m
Nominal Diameter	0.53mm ID	0.53mm ID	0.53mm ID
Film Thickness	5um	5um	NA
DETECTOR			
Make-up Gas	35mL/min	40mL/min	30mL/min (N2)
Hydrogen Flow	35mL/min	36mL/min	30mL/min
Air Flow	400mL/min	375mL/min	350mL/min

11.4 Initial Calibration

The instrument must be calibrated initially and whenever the laboratory takes corrective action (maintenance), which may change or affect the initial calibration criteria, or if the continuing calibration acceptance criteria have not been met. Introduce each initial calibration concentration standard (at least five levels, analyzed from low concentration to high concentration) by direct injection using a gas tight syringe. Perform all calibration runs according to the analytical portion of the sample analysis described in Section 11.8.

Note: The concentrations of the initial calibration may change as long as the low standard analyzed is the same as the reporting limit for each analyte or lower.

Refer to Section 13.1 for the required calculations and Section 12.1 for the acceptance criteria and corrective action.

11.4.1 Initial Calibration Requirements

Once a set of ICAL standards is analyzed and used to report samples, the previous ICAL may no longer be used to analyze new samples and it must be archived. The only time an archived ICAL can be used thereafter is to review or re-evaluate samples(s) previously processed using that ICAL.

1. A minimum of 5 concentrations must be used to calculate the calibration curve.
2. Highest concentration, together with the lowest concentration, defines the calibration curve.
3. Lowest concentration must be at or below the method reporting limit.
4. A blank should be analyzed prior to beginning the analysis of the calibration standards.
5. The initial calibration event may not be interrupted by maintenance.
6. Only one value per concentration may be used.
7. Analyze calibration standards from low to high concentration.
8. All ICAL analyses must be completed within 48 hours.

9. If 5 calibration standards are in the ICAL, one standard may be re-analyzed. If 6 to 10 calibration standards are in the ICAL, two calibration standards may be re-analyzed.
10. Point dropping policy
    - Minimum of 5 consecutive concentrations must be used to calculate the calibration curve.
    - Lowest concentration must be at the MRL and may not be dropped unless the MRL is changed to the concentration of the remaining lowest standard.
    - Points at high end may be dropped, but doing so lowers the calibration curve.
    - Points may not be dropped from the interior of the curve unless an assignable cause (i.e., gross dilution or standard preparation error, or instrument malfunction) is accounted for and documented in a nonconformity and corrective action report (NCAR). In these instances, all the analytes in that calibration standard must be dropped from the calibration curve as the corrective action.
    - If a point or a calibration standard is dropped, the reason must be documented (and the results maintained with the documentation for the final ICAL).
    - A calibration standard may be re-analyzed if the first analysis of the standard has been dropped and other requirements in this policy are met (i.e., still within 48 hours).
    - Once the ICAL has been used to calculate and report sample results, it is not to be changed.
11. Concentrations for calibration curves can been found in Attachment E and Attachment F. However these concentrations might change due to the availability of the standards. Other concentrations can be used as long as all other guidelines for the analysis of initial calibration are followed (section 11.4.1).

11.4.2 Initial Calibration Review

Analyst's calculations and assessment along with a peer review of all ICAL data and documentation as stated in Attachment B is required before the ICAL may be used to analyze samples. Sample results may only be reported if the ICAL is reviewed and found to be acceptable.

11.4.3 Initial Calibration File

An ICAL file is to be created for each initial calibration performed per instrument into which is placed the following ICAL documents. The file shall remain in the laboratory and be filed by instrument and date.

- ICAL Checklist filled out, reviewed and approved
- Blank analysis quantitation report

- Calibration status report (a.k.a. Calibration History)
- Relative Response Factor Report / Percent Relative Standard Deviation
- Quantitation report for each calibration standard (including manual integration documentation – before and after manual integration)
- ICV quantitation report and evaluate continuing calibration report (a.k.a. Percent Difference Report)

11.4.4 Initial Calibration Verification Verify the initial calibration by analyzing an independent calibration verification standard (ICV). Refer to Section 13.2 for the required calculations and Section 12.2 for the acceptance criteria and corrective action.

11.4.5 LOQ Establishment, Verification & Acceptance Criteria

A) The LOQ must be set within the calibration range (≥ low std. of the current passing ICAL) prior to sample analysis.
B) The LOQ for each analyte must be > the analyte's LOD.
C) Initially a passing demonstration of precision and bias must be performed at the LOQ
D) Run CCV 2 times at the LOQ and:
   1) Evaluate the LOQ for precision and bias using current control chart limits.
   2) Check the signal to noise ratio (S/N) using the software. The S/N ratio must be at least 3:1 for each analyte.
E) If anything fails, verify at higher level and notify reporting. Also, make a note in the ICAL documentation.
F) Turn in all LOQ verification data (quant reports and software reports/checks) to QA (regardless of pass/fail).
G) Verify the LOQ on each instrument quarterly by running the CCV at the LOQ and verifying that ongoing precision and bias requirements are met.

11.5 Continuing Calibration Verification

A continuing calibration check shall be performed at the beginning, after every 10 samples and at the end of an analytical sequence, or every twenty field samples, not to exceed a 24-hour period. The concentration of the calibration verification may be varied within the established calibration range. Refer to Section 13.3 for the required calculations and Section 12.3 for the acceptance criteria and corrective action.

11.6 Method Blank

The method blank shall be obtained using ultra high purity nitrogen directly injected in the same manner as the standards and samples. A method blank must be analyzed prior to analysis of samples. A method blank must also be analyzed if carryover contamination is suspected. Refer to Section 12.4 for the acceptance criteria and corrective action.

11.7 Laboratory Control Sample

The laboratory control sample shall be an injection of the continuing calibration or initial calibration verification standard. Make sure that all of the pertinent information is included on the quantitation report including the sample identification (LCS), concentration, standard used, and analyst. Refer to Section 13.4 for the required calculations and Section 12.5 for the acceptance criteria and corrective action.

11.8 Analysis

11.8.1 Canister Pressurization Sample analysis must be made using the same instrument parameters as that of the calibration standards. Refer to the ***SOP for Evaluation and Pressurization of Specially Prepared Stainless Steel Canisters*** for the procedure of how canisters are to be pressurized prior to analysis. The analyst shall record the appropriate pressures on the Service Request form. This includes noting the difference between the initial (as received pressure) and the pressure prior to pressurization for which the appropriate corrective actions have been detailed and must be followed accordingly.

11.8.2 Sample Analysis Sample analysis shall be performed by a direct injection technique using gas tight syringes. Insert the syringe through the tedlar bag septum or summa can fitted with an adapter. When using adapters and fittings the dead volume must be evacuated and replaced with the sample gas prior to sampling from the container. The sampling syringe shall then be flushed with the sample gas to remove residual ambient air and vented into a waste bag. This procedure entails drawing an aliquot greater than is needed, and adjusting the syringe plunger to the appropriate volume *immediately* before injecting. Refer to Section 13.5 for the required calculations and Section 12.6 for the acceptance criteria and corrective action.

11.8.3 Sample Dilution If any target analyte results are above the highest level of the initial calibration, a smaller sample aliquot or a dilution in a Tedlar bag or glass dilution bomb must be analyzed. Guidance in performing dilutions and exceptions to this requirement are given below.

- Use results of the original analysis to determine the approximate dilution factor required getting the largest analyte peak within the initial calibration range.
- The dilution factor chosen should keep the response of the analyte peak for a reported target compound in the upper half of the initial calibration range of the instrument. Additional compounds may be reported as long as they are within the calibration range.
- Analysis involving dilution should be made with high purity nitrogen and must be reported with a dilution factor.

Tedlar bag dilution:

- Calculate the sample amount and volume of balance gas needed to obtain the required dilution.

- Fill a new 1.0L tedlar bag with nitrogen using the appropriate gas tight syringe.
- Remove the difference in the balance gas using the appropriate gas tight syringe.
- Add the calculated sample amount using a gas tight syringe.

11.8.4 Quantitative Analysis Prior to integration, verify that each peak is within calibration range. A smaller injection volume or dilution may be required. Integrate the entire range of hydrocarbons that elute prior to and include the n-alkane peak (Branched alkanes of the same molecular weight will elute prior to the n-alkane.). For example, C3 as propane, integrate the range of peaks that elute after the ethane peak to the end of the propane peak.

The >C6 as hexane may be integrated as one group or separated into >C6_1 as hexane and >C6_2 as hexane. If the analysis is for the n-chain alkanes and alkenes only, manual integration is generally unnecessary unless the peaks are misidentified, not integrated or the baseline needs to be adjusted. Refer to Section 11.10 for manual integration guidelines.

11.9 Laboratory Duplicate

Analyze two separate aliquots from the same sample container. A laboratory duplicate must be analyzed a frequency of 1 in 20 field samples. The laboratory duplicate should be rotated among clients, whenever possible. Refer to Section 13.6 for the required calculations and Section 12.7 for the acceptance criteria and corrective action.

11.10 Manual Integration

For single component analysis, the integration(s) for each sample is checked to ensure that it has been integrated properly. For the hydrocarbon range analysis the computer software is not programmed to perform the integration; therefore, manual integration must be performed. In this instance, the software integrations of a before chromatograph printout is not necessary. Assuming an incorrect automatic integration the analyst shall conduct the manual integration in accordance with the ***SOP for Manual Integration of Chromatographic Peaks*** including all documentation and reviews associated with the process. The review should include the analyst and peer reviewer initialing and dating the manual integration as an indication of acceptability and approval.

Client samples that are received in Tedlar bags may have the noticeable artifacts of N,N-dimethylacetamide and Phenol from the Tedlar manufacturing that is above the reporting limit for the greater than C6 portion of the chromatogram. These peaks may have to be excluded from the manual integration process if they add an amount of area that will lead to a false positive result. The retention time of these peaks have been identified and are maintained on file.

11.11 Detection Limits and Limits of Detection

If results are to be reported below the MRL, an MDL study must be performed in accordance with the procedure outlined in the ***SOP for Performing Method Detection Limit Studies and Establishing Limits of Detection and Quantiation***. Method detection limits must be determined annually and each time there is a change in the test method that affects how the test is performed, or when a change in instrumentation is such that it affects the sensitivity of the analysis. The MDL study shall be performed on each instrument. All supporting data must be approved and retained.

The detection limit shall be used to determine the LOD for each analyte. Once determined on each instrument, the highest LOD (for each analyte from all instrument determinations) shall be used as the uniform LOD.

11.11.1 Performance and Acceptance Criteria

1. Perform Limit of Detection (LOD) verification on all instruments (performing this method) immediately following the MDL study. Spike the LOD at 1-4x the MDL; the spike level establishes the LOD.
2. LOD Acceptance
   - Analyte must be detected reliably and identified by the method-specific criteria and produce a signal that is at least 3 times the instrument's noise level (3:1 signal to noise ratio).
   - It is specific to each combination of analyte, matrix, method and instrument configuration.
   - The LOD must be verified quarterly on each instrument (spiked at LOD) using the criteria listed above.
3. If the LOD verification fails (per #2), repeat the detection limit determination and LOD verification at a higher concentration **or** perform and pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration.
4. The laboratory shall maintain documentation for all detection limit determinations **and** LOD verifications (regardless of pass or fail).

Note: Per DoD and TNI / NELAC Standard, it is not necessary to perform a MDL study when results are not to be reported below the LOQ/MRL.

11.12 Cleaning Tedlar Bags and Static Dilution Bombs

Tedlar Bags –Fill with nitrogen and evacuate several times. In the final cleaning step partially fill the bags with nitrogen, heat at 60°C for 20 minutes, and evacuate using a pump.

Static Dilution Bombs – Heat to 60°C for 30 minutes and purge for ~30 seconds from the liquid nitrogen dewer.

11.13 Storing Electronic Data

The initial calibration data must be stored in a quantitation method (on the server) using a unique filename and may not be overwritten at any time in order to maintain an accurate audit trail. There are multiple quantitation methods, which are subsets of the compound list in Attachment D. Therefore, files should be named with a two-character notation indicating the compound list and the date of the corresponding initial calibration. In addition, all data files including method blanks, continuing calibration verification, laboratory control samples and client submitted samples files shall be saved in a unique sub-directory on the server. An example of how the analyst should store analytical data is as follows:

Instrument Number/Data/Method ID/yr_month/*.d

12.0 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

This section of the standard operating procedure contains technical acceptance criteria and preferred corrective actions to data nonconformities. Corrective actions shall follow the procedures outlined in the ***SOP Corrective Action***, where appropriate.

To the extent possible, samples shall be reported only if all of the quality control measures are acceptable. If a quality control measure is found to be out of control, and the data must be reported, all samples associated with the out of control quality control measure shall be reported with the appropriate data qualifier(s).

12.1 Initial Calibration

12.1.1 Acceptance Criteria The percent relative standard deviation (%RSD) of the analytes of each of the levels must be less than 20% for the calibration to be considered acceptable.

12.1.2 Corrective Action If the initial calibration technical acceptance criteria are not met, inspect the system for possible sources. It may be necessary to change the column or take other corrective actions to meet the initial calibration technical acceptance criteria. Also, check standards for a bad injection and re-analyze standard. If a bad injection is not evident, perform maintenance and attempt another initial calibration (make notation in maintenance logbook regarding any steps taken). A demonstration of an in-control system is required before proceeding with the analysis.

Note: No ICAL may be interrupted by any maintenance procedure; therefore, all the ICAL standards must be reanalyzed.

12.2 Initial Calibration Verification Standard (ICV)

12.2.1 Acceptance Criteria The percent difference (%D) for each calculated target analyte must be within ±15% of the actual concentration of the standard.

12.2.2 Corrective Action If the initial calibration verification fails to meet the acceptance criteria, it should be re-analyzed. A second failed ICV must initiate corrective action and two consecutive standards must pass in order for the ICAL to be deemed acceptable. It may be necessary to prepare either new ICAL or ICV standards or both, perform maintenance and reanalyze the initial calibration.

12.3 Continuing Calibration Verification (CCV)

12.3.1 Acceptance Criteria The percent difference (%D) for each calculated target analyte must be within ±15% of the actual concentration.

12.3.2 Corrective Action If the criteria are not met, reanalyze (no more than two injections may be made before corrective action is initiated) or prepare a fresh CCV standard and reanalyze. If routine corrective action procedures fail to produce an acceptable calibration verification, a new initial calibration must be performed. However, sample data associated with unacceptable calibration verification may be reported as qualified data only under the following special condition:

When the acceptance criteria for the continuing calibration verification are exceeded high, i.e., high bias, and there are associated samples that are non-detects, then those non-detects may be reported. Otherwise the sample affected by the unacceptable CCV shall be reanalyzed after a new calibration curve has been established, evaluated and accepted.

12.4 Method Blank

12.4.1 Acceptance Criteria The method blank result for any target analyte must not be greater than the method reporting limit or contribute more than 10% of the sample concentration.

For DoD samples, the method blank will be considered to be contaminated if:

1.) The concentration of any target analyte in the blank exceeds 1/2 the reporting limit and is greater than 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater);
2.) The concentration of any common laboratory contaminant in the blank exceeds the reporting limit and is greater than 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater); or
3.) The blank result otherwise affects the samples results as per the test method requirements or the project-specific objectives.

The laboratory shall evaluate whether reprocessing of the samples is necessary based on the above criteria.

12.4.2 Corrective Action If the analyte results in the blank do not meet the acceptance criteria the source of the problem must be investigated and measures taken to eliminate the source. Determine whether the contamination is from the instrument or due to contamination in the nitrogen, syringe or other source. Regardless, appropriate corrective measures must be taken and documented before further sample analysis proceeds. *If the results are the same, the blank along with all associated samples must be reported to the client with the appropriate qualifier as specified in Section 17.0.*

12.5 Laboratory Control Sample (LCS)

12.5.1 Acceptance Criteria The percent recovery must be within the control limits designated in Attachment D (unless updated after the revision of this document, refer to the most current control limits). Fixed limits of 70-130 will be used if insufficient points are available to generate control charts.

12.5.2 Corrective Action If the LCS criteria are not met, determine whether the cause is instrumentation or the result of a poor injection. If the problem is instrumentation, perform maintenance and reanalyze the associated sample(s). If the problem is with the injection, reanalyze the LCS. If the results are still unacceptable and there does not appear to be any instrumentation problems refer to Section 17.0 for the appropriate reporting information.

12.6 Sample Analysis

Sample results must be quantitated from the current instrument initial calibration and may not be quantitated from any continuing calibration verification standard.

12.6.1 Acceptance Criteria The field samples must be analyzed along with a laboratory method blank that has met the blank criteria in Section 12.4. All target analyte peaks must be within the initial calibration range.

12.6.2 Corrective Action To the extent possible, samples shall be reported only if all of the quality control measures are acceptable. If a quality control measure is found to be out of control, and the data must be reported, all samples associated with the out of control quality control measures shall be reported with the appropriate data qualifier(s) as detailed in this document and the most current Quality Assurance Manual.

- When corrective actions are made, samples analyzed while the system was not functioning properly must be reanalyzed.

- Results not bracketed by initial instrument calibration standards (within calibration range) must be reported as having less certainty, e.g., defined qualifiers or flags.

12.7 Laboratory Duplicate

12.7.1 Acceptance Criteria The selected samples must be rotated among client samples so that various matrix problems may be noted and/or addressed. The results must meet all of the criteria stated in Section 12.6.1 as well as meet the relative percent difference criteria stated in Attachment D. A fixed RPD of 25 will be used if insufficient data points are available for control charts.

12.7.2 Corrective Action If the replicate results do not fall within the technical acceptance window, the sample should be re-analyzed. If the results are still unacceptable and there does not appear to be any matrix effects, interfering peaks, or instrument problems, the results for both injections shall be reported to the client with the appropriate qualifier as specified in Section 17.0.

13.0 DATA REDUCTION AND REPORTING

The essential information to be associated with analysis, such as computer data files, run logs, etc. shall include: Sample ID code, date of analysis, time of analysis, instrument operating conditions/parameters (or reference to such data), analysis type, any manual calculations including dilutions and manual integrations, analyst's initials, sample preparation (pressure readings), standard and reagent origin, sample receipt, calibration criteria, frequency and acceptance criteria, data and statistical calculations, review, confirmation, interpretation, and assessment and reporting conventions.

13.1 Initial Calibration

The initial calibration curve must be saved with a two-character identification (C1) followed by the date of the analysis (mmddyy). This file shall be saved in an appropriate directory (J:\GC#\Method\). No curve may be overwritten at any time to ensure a complete audit trail.

- Tabulate the peak area along with standard concentration injected to determine the response factor (RF) for each analyte at each concentration using equation number 1.
- Calculate the percent relative standard deviation (%RSD) of the mean RF (equation number 2) for each analyte over the range of each concentration of the calibration standards using equation numbers 4 and 5.

13.2 Initial Calibration Verification

- Calculate the concentration for each analyte using equation number 3.
- Calculate the percent difference (%D) between the calculated concentration (equation number 3) and the actual concentration using equation number 6.

13.3 Continuing Calibration Verification

- Calculate the concentration of each analyte using equation number 3.
- Calculate the percent difference (%D) between the calculated concentration (equation number 3) and the actual concentration using equation number 6.

13.4 Laboratory Control Sample

- Calculate the concentration of each analyte using equation number 3.
- Calculate the percent recovery (%R) for each analyte using equation number 8.

13.5 Sample Analysis

- Calculate the concentration of each range using equation number 3.
- Calculate the dilution factor if necessary using equation number 9.

13.6 Laboratory Duplicate

- Calculate the concentration of each range using equation number 3.
- Calculate the relative percent difference (RPD) using equation number 7.

13.7 Calculations

13.7.1 Equation Number 1

Response Factor (RF)

The response factor, for analyte *x* is given by:

$$RF = \frac{A_x}{C_x}$$

where:
A_x = Area of the analyte in the standard
C_x = Concentration of the analyte in the standard

13.7.2 Equation Number 2

Average (or Mean) RF

$$\overline{RF} = \frac{\sum_{i=1}^{N} RF_i}{N}$$

where:

RF_i are the individual RFs from each concentration level in the initial calibration curve.
N is the number of calibration concentration levels.

13.7.3 Equation Number 3

Concentration (C):

$$C = \frac{Area}{\overline{RF}} \times \frac{D_{inj}}{A_{inj}}$$

where:

Area is the area obtained from the chromatogram
$\overline{RF}$ Average (or Mean) RF of all concentration levels in the initial calibration curve
D_{inj} default injection volume (mL)
A_{inj} actual injection volume (mL)

13.7.4 Equation Number 4

Standard Deviation, SD:

$$SD = \sqrt{\sum_{i=1}^{N} \frac{\left(RF_i - \overline{RF}\right)^2}{N-1}}$$

where:

RF_i are the individual RFs from each concentration level in the initial calibration curve.
$\overline{RF}$ Average (or Mean) RF of all concentration levels in the initial calibration curve.
N total number of calibration concentration levels

13.7.5 Equation Number 5

Percent Relative Standard Deviation, %RSD:

$$\%RSD = \frac{SD}{\overline{RF}}(100)$$

where:

SD Standard Deviation calculated in equation number 3

$\overline{RF}$ Average or Mean RF

13.7.6 Equation Number 6

Percent Difference, %D,

The %D is used for evaluating ICV and CCV vs. the initial calibration

$$\%D = \frac{C_{CCVorICV} - C_{std}}{C_{std}}(100)$$

where, for any given analyte:

$C_{CCVorICV}$ is the concentration being evaluated
C_{std} is the concentration from the current calibration curve

13.7.7 Equation Number 7

Relative Percent Difference (RPD)

$$\frac{|R_1 - R_2|}{\left(\frac{R_1 + R_2}{2}\right)} x100$$

where:

R_1 First measurement value
R_2 Second measurement value

13.7.8 Equation Number 8

Percent Recovery (%R):

$$\%R = \frac{C}{S} x100$$

where

C = Concentration of the analyte recovered
S = Spiked amount

13.7.9 Equation Number 9

Dilution Factor

$$DF = \frac{V_T}{V_S}$$

Where:

DF = dilution factor
V_S = volume of sample (mL) used
V_T = total volume of dilution (mL)

13.8 Data Review

The analyst must review data on a real time basis for all calibration and QC data. The QC data must be evaluated following the data review checklist in Attachment C. The data shall be reviewed and the sample results calculated and assessed by one analyst and reviewed by a second qualified analyst (Refer to Section 10.0). The data review checklist shall be used to document the review process. Once it has been completed, the checklist must be initialed, dated and filed with each job file.

Initial calibrations must be reviewed in the same manner as QC data with all ICAL documentation retained in a separate file. Refer to the initial calibration checklist in Attachment B for the review guideline. The ICAL file must contain all the pertinent information stated in Section 11.4.3.

13.9 Reporting

The results of each test shall be reported clearly, unambiguously and objectively, and shall include all the information necessary for the interpretation of the test results. The analyst shall ensure that all of the requirements specified in this document and the ***SOP for Data Review and Reporting***.

14.0 METHOD PERFORMANCE

An on-going assessment of method performance is conducted in order to ensure that the laboratory is capable of reporting results which are acceptable for its intended use. Validation of the method is confirmed by the examination and provision of objective evidence that these requirements are met.

14.1 Method Detection Limit (MDL)

The procedure used to determine the method detection limits are as stated in the *Code of Federal Regulations* (40 CFR 136 Appendix B) as defined in the ***SOP for Performing Method Detection Limit Studies and Establishing Limits of Detection and Quantitation***. The MDL is defined as the minimum concentration of a substance that can

be measured and reported with 99% confidence that the value is above zero. MDLs can be obtained using standards at a concentration of about 0.1ppm and making at least seven replicate measurements of the compounds of interest, computing the standard deviation, and multiplying this value by the appropriate Student's t value for 99 percent confidence.

The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects. Refer to Section 11.11.1 for the LOD verification criteria.

Note: Per DoD and TNI / NELAC Standard, it is not necessary to perform a MDL study when results are not to be reported below the LOQ/MRL.

14.2 Accuracy and Precision

Refer to Section 12.7 for information on replicate precision criteria for method performance. Single laboratory accuracy is presented as the second source initial calibration verification standard, which meets the method performance criteria of 15%. Additionally, laboratory generated control limit data for LCSs are presented for the analytes of interest and may be referenced in attachment D. Refer to Section 11.4.5 for the accuracy and precision LOQ requirements.

14.3 Demonstration of Capability

This laboratory has continuously performed this method since before July 1999. Ongoing demonstration of capable shall be performed and documented; however, the initial demonstration of method capability is not required.

15.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

All waste management must be carried out in accordance with the requirements detailed in the ***SOP for Waste Disposal*** as well as the Health and Safety Manual.

16.0 CORRECTIVE ACTIONS FOR OUT-OF-CONTROL DATA

It must be determined if there are any instrumentation problems contributing to the occurrence of any out of control data. If it is decided that problems do exist then the analyst must determine if the effects have caused any modification in the data from client submitted samples. This being the case, all samples (including QC) that are affected by instrumentation problems must be re-analyzed following any necessary maintenance activity.

Refer to Section 12.0 for the corresponding recommended or required corrective actions for out of control data.

16.1 Sample Holding Time Expired

The client is to be notified (best attempt) that the sample's holding time was missed and the client is to decide if the sample analysis shall continue. The documentation of missed

holding time and the client's decision to proceed must be included in the corresponding job file. A statement dictating all holding time occurrences must accompany the sample results in the final report.

17.0 CONTINGENCIES FOR HANDLING OUT-OF-CONTROL OR UNACCEPTABLE DATA

17.1 When analysis quality control results (CCV, MB, LD, and LCS recoveries) are out-of-control:

If the associated samples are within holding time, re-analyze the sample. Alternatively, evaluate the effect on the sample results and report the results with qualifiers and/or discuss in the case narrative as detailed below.

17.1.1 CCV: Refer to Section 12.3.2 for specific information on reporting data with an unacceptable continuing calibration verification standard (biased high).

17.1.2 Method Blank: If an analyte in the blank is found to be out of control and the analyte is also found in associated samples, those sample results shall be "flagged" in the report. If the analyte is found in the blank but not in the sample and all other quality control meets acceptance criteria then the results for the sample may be reported without a qualifier. However, if other QC is out of control then an evaluation must be made and the results reported accordingly.

17.1.3 Laboratory Control Sample All samples processed with an out of control LCS will require re-analysis or data qualifiers to be attached to the analytical results.

17.1.4 Laboratory Duplicate The appropriate data qualifier must be included for results associated with an out-of-control laboratory duplicate and/or discussed in the case narrative.

17.2 When sample quality control results are out-of-control:

Examine the sample results for matrix interference and for carryover. Reanalyze the sample(s) and/or reanalyze the sample(s) at a lower aliquot. If the out-of-control results are due to matrix interference, report the results with a matrix interference qualifier.

Holding time qualifiers must be included for those samples not analyzed within holding time.

18.0 REFERENCES

18.1 EPA Compendium Method TO-3, **"**Method for the Determination of Volatile Organic Compounds in Ambient Air using Cryogenic Preconcentration Techniques and Gas Chromatography with Flame Ionization and Electron Capture Detection", Revision 1, April 1984.

18.2 *Department of Defense Quality Systems Manual for Environmental Laboratories*, Version 4.2, 10/25/2010.

18.3 National Environmental Laboratory Accreditation Conference, Chapter 5; *Quality Systems,* June 5, 2003 and 2009 TNI Standards.

19.0 TRAINING PLAN

Training shall be conducted in accordance with the ***SOP for Documentation of Training***. An initial demonstration of proficiency shall be performed prior to independent analyses of samples. In addition, a continuing demonstration must be performed annually. See Attachment A for the training plan.

19.1 Demonstration of Capability

Demonstrations are to be performed in accordance with the SOP stated above in 19.0 and TNI / NELAC standards and DoD QSM 4.2 (Requirement Box 25). Additionally, these demonstrations are performed anytime there is a change in instrument type, personnel or method; refer to Section 19.1.3 below for additional information.

Once performance is found to be acceptable, a required certification statement must be completed by the QA Program Manager and either the immediate supervisor or Laboratory Manager and retained on file as a demonstration of compliance.

19.1.1 Quarterly Demonstration A demonstration of method sensitivity must be performed *quarterly on each instrument* performing this method.

1) A spike at the current LOD must be analyzed.
2) Verification of precision and bias at the LOQ must be performed.

Refer to Section 11.4.5 (LOQ) and 11.11.1 (LOD) for additional information on how these demonstrations are to be performed as well as the acceptance criteria.

19.1.2 Annual Demonstration Each analyst must perform this demonstration both initially and annually. Analyze four LCS standards at 1-4x the MRL (LOQ) either concurrently or over a period of days as a verification of precision and bias of the quantitation range. The standard deviation (n-1) and average percent recovery of the four replicates are compared against current laboratory control limits for precision and bias. See attachment D.

19.1.3 Change in Personnel, Instruments, Method and/or Matrix The requirements in Sections 19.1.1 and 19.1.2 must be performed per the schedule noted and when there is a change in personnel, instruments, method or matrix. “Change” refers to any change in personnel, instrument, test method, or sample matrix that potentially affects the precision and bias, sensitivity, or selectivity of the output (e.g., a change in the detector, column type, matrix, or other components of the sample analytical system, or a method revision).

All attempts at this demonstration must be completed and turned into the QA department for retention.

20.0 METHOD MODIFICATIONS

The modification includes the fact that the analysis is conducted without cryogenic preconcentration. In addition, the sample is introduced onto the system using a manual injection technique with a gas-tight syringe.

21.0 INSTRUMENT-SPECIFIC ADDENDUM

Not Applicable

22.0 CHANGES FROM PREVIOUS REVISION

Section 5.0	Updated waste management plan to SOP for Waste Disposal
Section 8.4	Revised for accuracy and added reference to SOP
Section 9.2.1	Added "Decreasing" to beginning of third paragraph
Section 11.1	Fixed SOP title
Section 11.4.1	Corrected attachment letters under number 11
Section 12.7.2	Corrected section reference
Section 11.10	Added second paragraph
Section 11.11.1	Revised note to include 2009 TNI standards
Section 13.1	Generalized the ICAL save directory
Section 13.9	Revised to refer to SOP instead of QAM for Reporting
Section 14.1	Revised note to include 2009 TNI standards
Section 14.3	Revised note to reflect 2009 TNI requirements
Section 18.2	Updated Reference
Section 18.3	Updated Reference
Section 19.1	Updated to DoD 4.2 and TNI 2009
Attachment A	Updated
Attachment C	Updated
Attachment D	Updated
Attachment E	Condensed onto one page
Attachment F	Condensed onto one page

23.0 ATTACHMENTS

Attachment A: Training Plan for Analysis of C_1-C_6+ by GC
Attachment B: Initial Calibration Checklist
Attachment C: Data Review Checklist
Attachment D: Target Analytes with Corresponding Method Reporting and Control Limits
Attachment E: Calibration Curve Concentrations (GC07 and GC08)
Attachment F: Calibration Curve Concentrations (GC10)

Attachment A

**Training Plan for Analysis of C_1-C_6+ by
Gas Chromatography with Flame Ionization Detection
per Modified EPA Compendium Method TO-3**

Training Plan for Analysis of C_1 to C_6 Hydrocarbons by GC/FID

SOP Title: Analysis of C_1 to C_6 Hydrocarbons by GC/FID Revision:_____ Date:_____

Trainee:_____ Trainer:_____ Instrument:_____

1. **Read SOP: VOA-TO3C1C6** Trainer: ____ Trainee: ____ Date: _____
2. **Read Method: EPA Compendium Method TO-3** Trainer: ____ Trainee: ____ Date: _____
3. **Demonstrated understanding of the scientific basis of the analysis**
   - Gas chromatography
   - Flame Ionization Detector

   Trainer: ____ Trainee: ____ Date: _____
4. **Demonstrated familiarity with related SOPs** Trainer: ____ Trainee: ____ Date: _____
   - SOP for Batches and Sequences; Rev. ____
   - SOP for Making Entries into Logbooks and onto Analytical Records; Rev. ____
   - SOP for Manual Integration of Chromatographic Peaks; Rev. ____
   - SOP for Significant Figures; Rev. ____
   - SOP for Performing Method Detection Limit Studies and Establishing Limits of Detection and Quantiation; Rev. ____
   - SOP for Corrective Action; Rev. ____
5. **Observe performance of SOP** Trainer: ____ Trainee: ____ Date: _____
   ___Sample preparation (gas-phase dilutions)
   ___Standard preparation
   ___Analytical sequence setup
   ___Initial calibration and initial calibration verification
   ___Continuing calibration verification
   ___Sample analysis
   ___EnviroQuant introduction
   ___Data reduction and reporting
6. **Perform SOP with supervision** Trainer: ____ Trainee: ____ Date: _____
   ___Sample preparation (gas-phase dilutions)
   ___Standard preparation
   ___Analytical sequence setup
   ___Initial calibration and initial calibration verification
   ___Continuing calibration verification
   ___Sample analysis
   ___EnviroQuant use
   ___Data reduction and reporting
7. **Independent performance of the SOP** Trainer: ____ Trainee: ____ Date: _____
   ___Sample preparation (gas-phase dilutions)
   ___Standard preparation
   ___Analytical sequence setup
   ___Initial calibration and continuing calibration verification
   ___Sample analysis
   ___EnviroQuant proficiency
   ___Data reduction and reporting
   ___Initial demonstration of competency
   ___Four consecutive laboratory control samples
8. **Instrument operation and maintenance** Trainer: ____ Trainee: ____ Date: _____
   ___GC and capillary column installation
   ___Detector (FID) setup and maintenance
   ___Data system

Attachment B

Initial Calibration Checklist
EPA Compendium Method TO-3 (Modified) for the Analysis of C_1-C_6+

Initial Calibration Checklist

C_1-C_6+ Analysis (Modified EPA Method TO-3)

Analysis: C_1-C_6+ per Modified TO-3 ICAL Date: _____
Instrument: ☐GC7 ☐ GC8 ☐GC10 ☐ GC_____

Analyst		Reviewer
☐	1. Is the required documentation in the ICAL file?	☐
	☐ Sequence report	☐
	☐ Blank analysis Quantitation Report	☐
	☐ Calibration Status Report (aka Calibration History) – Initial	☐
	☐ Response Factor Report	☐
	☐ Quantitation Report for each calibration standard (including manual integration documentation – before and after printouts)	☐
	☐ ICV Quantitation Report and Evaluate Continuing Calibration Report (aka Percent Diff. report)	☐
☐	2. Was the ICAL performed continuously (i.e., not interrupted for maintenance or or sample analysis)?	☐
☐	3. Was the ICAL performed within 24 hours?	☐
☐	4. Were the standards analyzed from low concentration to high concentration?	☐
☐	5. Are all the analytes in the blank analysis < MRL?	☐
☐	6. Does each analyte's ICAL include a minimum of 5 concentrations?	☐
☐	7. For each analyte, is there only one value used for each calibration level?	☐
☐	8. If a point is dropped, is information noted in the ICAL explaining the reason?	☐
☐	9. Does this follow the CAS point dropping policy (including re-analysis within 24 hrs)?	☐
☐	10. For each analyte, is the lowest standard's concentration at or below the MRL?	☐
☐	11. For each analyte, does the ICAL include 5 consecutive levels?	☐
☐	12. For each analyte, are there no levels skipped?	☐
☐	13. Does the calibration curve give a %RSD of <20%?	☐
☐	14. For the ICV analysis, is the percent recovery for each analyte 85-115%?	☐
☐	15. Are all peak integrations including manual integrations (per SOP on manual integrations) acceptable? ***If so, initial and date the appropriate pages.***	☐

COMMENTS:

Analyst: _____ Secondary Reviewer: _____
Date: _____ Date: _____

Attachment C

Data Review Checklist
C_1-C_6+ per Modified EPA Compendium Method TO-3

C_1-C_6+ per Modified EPA Method TO-3
Data Review Checklist
(Note exceptions in Comments Section and attach Nonconformity and Corrective Action Reports as appropriate)

Analysis Date: _____ Instrument: ☐GC7 ☐GC8 ☐GC10 ☐ GC___
Client: _____ QC level: _____
CAS Project #: _____ Due Date:_____

Analyst **Reviewer**

Initial Calibration:
☐ 1. Is the referenced ICAL the most recent ICAL performed?
☐ 2. Has the referenced ICAL been peer reviewed and all associated documentation including the ICAL review checklist available for review?
☐ 3. Were all associated requirements within the specified limits?

Continuing Calibration:
☐ 4. CCV raw data submitted? ☐
☐ 5. Was the %D for the CCV ≤15% between the calculated and actual concentration? ☐
☐ 6. Was a CCV analyzed at the beginning of the sequence, every 10 samples and the end of the sequence? ☐

Sample Data:
☐ 7. Is all sample data present and correct? ☐
___Sample raw data?
___All target analyte responses within calibration range?
___All peak integrations acceptable?
___All manual integrations flagged and properly documented? If so, initial and date.
___All calculations correct?
___First quantitation report initialed and dated by analyst?

QC Data:
☐ 8. Duplicate sample analyzed 1 per 20 or fewer samples? ☐
☐ 9. *Laboratory Duplicate* - For analyte concentrations greater than 10x the MRL, are the RPDs acceptable? ☐
(within the lab generated limits or 25% if lab generated limits not available)
☐ 10. Are all the analytes in the *MB* ≤MRL? ☐
☐ 11. Are all the analyte recoveries for the *LCS* within the generated limits?
(or 70-130% if lab generated limits not available)? ☐

Reporting Information:
☐ 12. Is a Sample Preparation and Analysis Observations / Case Narrative Summary completed if applicable? ☐
☐ 13. Are the appropriate flags indicated on a Sample Preparation and Analysis Observations / Case Narrative Summary form when applicable? ☐
☐ 14. **DOD:** Are manual integration notated in the case narrative? ☐

COMMENTS:

_____
_____
_____

Analyst: _____ Secondary Reviewer: _____
Date: _____ Date: _____

Attachment D

Target Analytes with Method Reporting and Control Limits
EPA Compendium Method TO-3 (Modified) for the Analysis of C_1-C_6+

Target Analytes with Method Detection Limits, Method Reporting Limits and Control Limits
EPA Compendium Method TO-3 (Modified) for the Analysis of C_1-C_6+

ANALYTE	GC 8 MDL PPM(MG/M3)	GC 8 MRL PPM(MG/M3)	GC 10 MDL PPM	GC 10 MRL PPM
Methane	0.11 (0.072)	0.50 (0.33)	0.36	1.0
Ethene			0.11	0.25
Ethane	0.057 (0.070)	0.50 (0.61)	0.11	0.25
Propene (Propylene)			0.12	0.25
Propane	0.055 (0.099)	0.50 (0.90)	0.11	0.25
Butane	0.044 (0.10)	0.50 (1.2)		
Pentane	0.049 (0.14)	0.50 (1.5)		
Hexane	0.064 (0.23)	0.50 (1.8)		
C6+	NA	1.0 (3.5)		
TGNMO as Hexane	NA	0.17 (0.60)[1]		
[1] The TGNMO MRL is based on the MRL for C6+/6 & converted to mg/m3.				

Note: The method detection and reporting limits may change with each new MDL study and ICAL performed, check the current documentation for verification.

CONTROL LIMITS

GC8

Analyte	LCS - LCL (%R)	LCS -UCL (%R)	LD (RPD)
Methane	**79**	**114**	**18**
Ethane	**83**	**123**	**22**
Propane	**82**	**124**	**22**
Butane	**85**	**123**	**22**
Pentane	**79**	**125**	**24**
Hexane	**65**	**138**	**34**
>C_6	**N/A**	**N/A**	**35***

* = limit did not change, not enough points

Note: New limits may be established prior to the revision of this document, refer to the most recent control limits.

Attachment E
Calibration Curve Concentrations
GC7 and GC8

Calibration Curve Concentrations (ppm unless noted as %)						
ICAL	Methane	Ethane	Propane	n-Butane	n-Pentane	n-Hexane
1	0.5	0.5	0.5	0.5	0.5	0.5
2	2	2	2	2	2	2
3	50	50	50	50	50	50
4	500	500	500	500	500	500
5	1000	1000	1000	1000	1000	1000
6	1%	1%	1%	1%	1%	
7	3%					
8						5000

ICAL	**Amount of standard spiked onto instrument**
1	0.05 ml of a 10ppm C1 to C6 standard[1]
2	0.2 ml of a 10ppm C1 to C6 standard[1]
3	0.05 ml of a purchased 1000ppm C1 to C6 standard (see section 8.2.1.1)
4	0.5 ml of a purchased 1000ppm C1 to C6 standard (see section 8.2.1.1)
5	1.0 ml of a purchased 1000ppm C1 to C6 standard (see section 8.2.1.1)
6	1.0 ml of a purchased 1% C1 to C6 standard (see section 8.2.1.1)
7	0.75 ml of a purchased 4% methane standard
8	1.0 ml of a 5000ppm n-hexane standard[2]

[1] 10ppm standard is made by introducing 10 ml of a purchased 1000ppm standard into 990 ml of nitrogen in a Tedlar bag.

[2] An approximate 5000ppm n-hexane standard is made by introducing 30ul of 99%+ n-Hexane into 1 liter of nitrogen in a Tedlar bag. The calculation is as follows with the following constants. The density of n-hexane is 0.6548mg/ul. The gas constant is 24.46L/mole at 25degrees C and 1 atm. The molecular weight of n-hexane is 86.18g/mole.

30ul * 0.6548mg/ul = 19.644mg (spike in to 1 liter) = 19.644mg/L
19.644mg/L * 1000L/M3 = 19644mg/M3
19644mg/M3 * 24.46 / 86.18 = 5575ppm

The Calibration Curve Concentrations Define the Calibration Range	
Methane	0.5ppm – 30000ppm
Ethane	0.5ppm – 10000ppm
Propane	0.5ppm – 10000ppm
n-Butane	0.5ppm – 10000ppm
n-Pentane	0.5ppm – 10000ppm
n-Hexane	0.5ppm – 5000ppm

Attachment F
Calibration Curve Concentrations
GC10

Calibration Curve Concentrations (ppm unless noted as %)					
ICAL	Methane	Ethene	Ethane	Propene	Propane
1	0.5	0.125	0.125	0.125	0.125
2	2	0.5	0.5	0.5	0.5
3	5	1.25	1.25	1.25	1.25
4	50	12.5	12.5	12.5	12.5
5	100	25	25	25	25
6	1000	250	250	250	250
7	4%				
8		5%			
9			5%		

ICAL	**Amount of standard spiked onto instrument**
1	0.05 ml of a 10ppm/2.5ppm MEEPP standard[1]
2	0.2 ml of a 10ppm/2.5ppm MEEPP standard[1]
3	0.5 ml of a 10ppm/2.5ppm MEEPP standard[1]
4	0.05 ml of a 1000ppm/250ppm MEEPP standard
5	0.1 ml of a 1000ppm/250ppm MEEPP standard
6	1.0 ml of a 1000ppm/250ppm MEEPP standard
7	1.0 ml of a purchased 4% methane standard
8	0.05 ml of a purchased 100% ethene standard
9	0.05 ml of a purchased 100% ethane standard

[1]10ppm/2.5ppm standard is made by introducing 1.25 ml of a standard that is 1000ppm methane and 250ppm all other analytes into a 125ml glass dilution bottle with UHP Helium.

The Calibration Curve Concentrations Define the Calibration Range	
Methane	0.5ppm – 40000ppm
Ethene	0.125ppm – 50000ppm
Ethane	0.125ppm – 50000ppm
Propene	0.125ppm – 250ppm
Propane	0.125ppm – 250ppm

B1.c. Lung Sampling Instruction Sheet

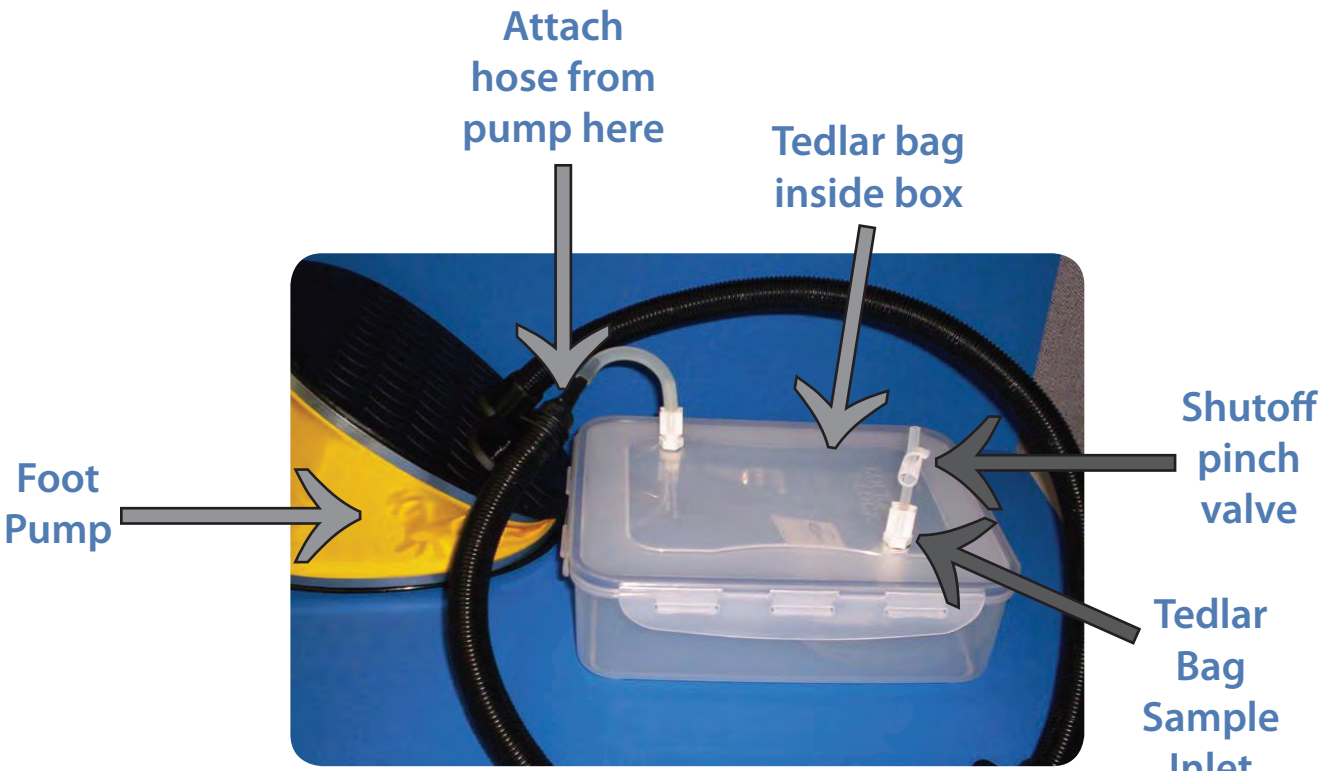
A lung sampler is a handy tool for collecting air samples in Tedlar bags. It allows you to collect an air sample in a Tedlar bag without passing air directly through a pump, thereby reducing the possibility of contaminating the pump, the sample and future samples. It does this by creating a vacuum inside the container, which forces the Tedlar bag to expand and to draw in an air sample through the tube not connected to the pump. The instructions below detail how to sample with this device.

1. Record the sample identification and sampling date and time on the label of the Tedlar bag.

2. Open up the container and place the Tedlar bag on the bottom of the container with the valve pointing upwards. Using the small piece of the silicon tubing attach the valve of the bag to one of the pieces of Teflon tubing (inlet). Open the valve on the bag by turning the white portion of the valve counter clockwise approximately 1 ¼ times.

3. Seal the container.

4. On the outside of the container attach the foot pump to the second piece of Teflon tubing (i.e. the piece of tubing that is NOT attached to the Tedlar bag inlet).



LUNG SAMPLER SETUP

more ⟶

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5. Before pumping, position the sampler so that the piece of tubing that is attached to the Tedlar bag (inlet) is collecting the sample from the location of concern.

6. Ensure that the inlet valve is not pinched shut.

7. Pump the foot pump one to two times.

8. The bag will begin to fill as a vacuum is created inside the container. You may hear a sucking sound as air enters the bag via the inlet.

9. Once the bag is ½ to ⅔ full, pinch closed the inlet valve on the outside of the container. Break the seal on the container and immediately close the valve on the bag.

Correctly Inflated Tedlar Bag

Additional Information:

Reduced sulfur compounds (i.e. hydrogen sulfide) samples (ASTM D5504-01) have a 24 hour holding time, while volatile organic compound samples (EPA TO-15) collected in Tedlar bags have a holding time of 72 hours.

The Tedlar bags should be packed in a box and shipped by overnight courier to the laboratory. Always include a completed chain of custody form with your samples.

B1.d. Canister Sampling Instruction Sheet

Canister Sampling Instructions

There are two primary modes of sampling: "GRAB" sampling and "TIME INTEGRATED" sampling. For GRAB sampling, the canister valve is simply opened and the vacuum inside the canister draws in a sample within a matter of seconds. GRAB sampling is most often used for discrete odor events, or for static concentration sample streams. TIME-INTEGRATED samples require an additional piece of laboratory calibrated equipment (flow controller or critical orifice) to be placed in line with the canister. Flow controllers/critical orifice assemblies are equipped with fine particulate filters and are set for any user-defined duration (or flow rate) from 5 minutes up to 24 hours.

Equipment

- Summa or Silco canister – cleaned and certified by Columbia Analytical, and leak checked prior to shipment. Canisters are available in several sizes, including 6L and 1L.

1L size canister with analog gauge and critical orifice assembly

- Flow controller (a.k.a. "regulator") – Used to collect a time-integrated indoor air or ambient air sample. Flow controllers are precisely calibrated by the laboratory for your project specific requirements. Do not adjust any of the settings or knobs on the flow controller.
- Critical Orifice Assembly (COA) – Used to collect a time-integrated soil gas, sub-slab, SVE system, or other vapor sample. COAs are precisely calibrated by the laboratory for your project specific requirements. Do not disassemble any parts on the critical orifice assembly.
- Analog gauge – Gauge on Swagelok ¼" Tee fitting, to monitor pressure during sampling. Note that these gauges are for general reference purposes only. Canister vacuum is checked prior to shipping and upon receipt at the laboratory after sampling using a NIST certified digital gauge. Clients are encouraged to purchase their own digital gauges for use in the field.

Procedure

1. Ensure that the canister valve is fully closed (the green knob should be turned completely clockwise).
2. Using a 9/16" wrench, remove the brass cap from the valve on the top of the Summa canister.
3. If collecting a GRAB sample, simply open the canister valve, turning the green knob counterclockwise until there is no resistance. This is approximately 1¼ turns. Then turn back clockwise slightly until resistance is detected. You will hear a hissing noise as the vacuum dissipates and draws air in. Then skip to step #7. If collecting a TIME-INTEGRATED sample, proceed to steps 4-6.
4. If desired, attach the analog gauge (on a Swagelok Tee) to the valve on the top of the canister. Tighten down with your fingers first, then tighten gently with 9/16" wrench.
5. Attach the flow controller or critical orifice assembly to either the analog gauge (if using) or directly to the valve on the top of the canister. Tighten down with your fingers first, then tighten gently with 9/16" wrench.

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6. To open the canister valve, turn the green knob counterclockwise until there is no resistance. This is approximately 1 ¼ turns. Then turn back clockwise slightly until resistance is detected. Since the flow controller restricts the airflow, you will NOT hear a hissing noise as the vacuum dissipates and draws air in.
7. At the end of the sampling period, close the canister valve by turning the green knob clockwise. Do not over-tighten.
8. Remove the flow controller/critical orifice assembly and/or analog gauge (used for time-integrated sampling only). Wrap both separately in bubble wrap for shipment.
9. Replace the brass cap on the canister valve. Tighten it with a 9/16" wrench.
10. Label the sample with the tag provided, then attach the tag to the canister with the plastic tie.
11. Complete a chain of custody form. Note the canister ID number on the COC. For time-integrated sampling, note the flow controller or critical orifice assembly identification number with the corresponding canister.
12. Place the chain of custody form, the bubble-wrapped flow controller, and the canister back into the original boxes in which they were shipped to you.

6L size canister with analog gauge and flow controller

Important Notes

- Care must be used with the canister valves. DO NOT OVER-TIGHTEN THE VALVES. Hand tighten only, do not use tools.
- Flow controllers must be securely wrapped in bubble wrap for shipping.
- The canister valve fitting is a ¼" male Swagelok fitting.
- The inlet side of the flow controller is a ⅛" outer diameter.
- The inlet side of the critical orifice assembly is ¼" outer diameter. A stainless steel ¼" nut with rubber ferrule will be provided to attach sample point tubing to critical orifice assembly.
- Do not remove the bar code or serial number labels from the canisters.
- Do not make any markings directly on the canister or affix any labels.
- 6L size canisters will be tagged as either "AMBIENT" (blue tag) or "SOURCE" (orange tag). AMBIENT canisters should be used for indoor or ambient air sampling. SOURCE canisters should be used for sub-slab, soil vapor, SVE system monitoring, landfill gas, source testing, or other types of samples. Please call the laboratory with any questions regarding the segregation of canisters.
- Flow controllers are calibrated such that some residual vacuum should remain after sampling. Please call the laboratory with any questions regarding pressures of canisters before or after sampling.
- Please call the laboratory with any questions regarding proper shipping of canisters.

Contact Information

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Simi Valley, California 93065

805.526.7161
805.526.7270 (fax)

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B2 Extractive Ammonia Sampling and analysis

B2.a. OSHA 188: Ammonia in Workplace Atmospheres – Solid Sorbent

For problems with accessibility in using figures and illustrations in this method, please contact the SLTC at (801) 233-4900.
These procedures were designed and tested for internal use by OSHA personnel. Mention of any company name or commercial product does not constitute endorsement by OSHA.

Ammonia in Workplace Atmospheres - Solid Sorbent

Related Information: Chemical Sampling - Ammonia

Method No.:	ID-188
Control No.:	T-ID188-FV-02-0201-M
Matrix:	Air
OSHA Permissible Exposure Limits* Final Rule Limit (ammonia): Final Rule Limits (ammonium chloride fume): (ammonium chloride fume or ammonium sulfamate):*	35 ppm [Short-Term Exposure Limit (STEL)] 20 mg/m^3 STEL* 10 mg/m^3 [Time Weighted Average (TWA)]*
Transitional Limit:	50 ppm TWA
Collection Device:	For ammonia collection, a personal sampling pump is used to draw a known volume of air through a glass tube containing carbon beads impregnated with sulfuric acid (CISA).
Recommended Sampling Rates TWA Determinations: STEL Determinations:	Ammonia 0.10 liter per minute (L/min) 0.5 L/min
Recommended Air Volume TWA: STEL:	Ammonia 24 L 7.5 L
Analytical Procedure:	The sample is desorbed with deionized water and analyzed as ammonium ion using an ion chromatograph.
Detection Limits Qualitative:	Ammonia 0.60 ppm (24-L air sample) 1.9 ppm (7.5-L air sample)
Quantitative:	1.5 ppm (24-L air sample) 4.8 ppm (7.5-L air sample)
Precision and Accuracy Validation Range: CV_T: Bias: Overall Error:	Ammonia 30.7 to 101.8 ppm 0.050 -0.009 ±10.9%
Method Classification:	Validated Method
January 2002	Robert G. Adler
* Note:	Ammonium chloride fume or ammonium sulfamate can be sampled and analyzed using this method. A mixed-cellulose ester filter, polystyrene cassette, and personal sampling pump (2 L/min) are used to collect the sample. Samples are analyzed by ion chromatography after resorption in deionized water.

Methods Development Team
Industrial Hygiene Chemistry Division
OSHA Salt Lake Technical Center
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1. Introduction

This method describes the sample collection and analysis of airborne ammonia. Ammonium chloride fume or ammonium sulfamate can also be analyzed using this method. Samples are taken in the breathing zone of workplace personnel and are analyzed by ion chromatography (IC).

1.1 History

1.1.1 Sampling:

The previous OSHA sampling procedure for ammonia involved the use of a midget fritted glass bubbler containing 0.1 N sulfuric acid (H_2SO_4) (8.1, 8.2). Bubbler sampling is inconvenient to use. It involves the use of a liquid which if spilled may be irritating to the skin or may damage sampling pumps. Also, the sample solutions may leak during shipment.

The present method employs glass tubes containing CISA which avoids liquid sampling media problems. It is based on a procedure described by Bishop, et. al. (8.3)

described by Bishop, et. al. (8.3).

1.1.2 Analysis:

Two analytical procedures have previously been used by OSHA. In the earliest procedure, ammonia was analyzed by a colorimetric method using Nessler reagent (8.2, 8.4). This method has significant interferences. The most recent method involved the use of the ammonia ion specific electrode (ISE) which does not discriminate between ammonia and amines (8.1).

The present method provides an analytical procedure which is easily set up and automated. Partial processing of the data is performed while the analysis is in progress.

1.1.3. An alternate screening technique for measuring ammonia exposures in the workplace involves the use of detector tubes (8.5). Other methods are needed to determine long-term ammonia concentrations since short-term detector tubes offer only spot checks of the environment.

1.2 Principle

A known volume of air is drawn through a sampling tube containing carbon beads impregnated with sulfuric acid (CISA). Ammonia is collected and converted to ammonium sulfate. Samples are desorbed using a known volume of deionized water (DI H_2O) and analyzed as ammonium ion by IC. For ammonium chloride fume or ammonium sulfamate, samples are collected on 0.8-µm mixed-cellulose ester filters, desorbed in DI H_2O, and also analyzed as ammonium ion by IC.

1.3 Advantages and Disadvantages

1.3.1 This method has adequate sensitivity for determining compliance with the OSHA permissible exposure limit (PEL) for workplace exposures to ammonia.

1.3.2 The method is simple, rapid, and easily automated.1.3.3 Previous IC methods for ammonia have described rapid loss of peak resolution resulting primarily from metal-column binding. Using equivalent equipment described in Section 6.2 eliminates eluent contact with metal surfaces, subsequent corrosion and rapid loss of resolution due to metals binding on the separator column.

1.3.4 Previous studies have also indicated changes in ammonium peak characteristics with changes in pH. When using the equipment and conditions described herein, retention times or peak shapes were not significantly affected when the diluent concentration was from 0.0001 to 0.02 N H_2SO_4. The peak characteristics were significantly different when a diluent of 0.1 N H_2SO_4 was used. (Note: due to the H_2SO_4 on the beads, a 25 mL solution volume = 0.02 N H_2SO_4).

1.3.5 Potential exposure to H_2SO_4 is reduced in comparison to previous methods for ammonia.

1.3.6. The analysis is specific for the ammonium ion (NH_4^+).1.3.7 After sample preparation (and acidification with additional H_2SO_4), ammonia can also be determined by the ISE analytical technique (8.1) or a calorimetric procedure (8.2).

1.3.8 One disadvantage is that ammonium salts present in the air as dust would constitute a positive interference; however, particulate will be captured in the glass wool plug preceding the acid-treated beads. A polystyrene cassette containing a mixed-cellulose ester filter can also be used as a prefilter to collect any particulate.1.3.9 Another disadvantage is the positive interference from monoethanolamine, isopropanolamine, or propanolamine. If present, these compounds will produce peaks in the vicinity of the ammonium ion when using this method. Mobile phase ion chromatography (8.6) can be used for confirmation of ammonia if these compounds are present.

1.4 CAS No. and Physical Properties (8.7, 8.8)

Ammonia

CAS No.	7664-41-7
Chemical formula	NH_3
Formula weight	17.03
Boiling point	-33.35°C
Melting point	-77.7°C
Density, gas (air = 1)	0.5967
Density, liquid	0.6818 (-33.35°C)
Critical temperature	132.4°C
Critical pressure	11.3×10^3 kPa
Autoignition temperature	651°C
Flammable limits	16-25% (by volume in air)
Solubility	
Cold water (0°C)	89.9 g/100 cc
Hot water (100°C)	7.4 g/100 cc
Color	Colorless
Lower limit of perception	Approximately 20 ppm

Ammonium chloride CAS No.	12125-02-9
Ammonium sulfamate CAS No.	7773-06-0
Chemical formula:	
Ammonium chloride	NH_4Cl
Ammonium sulfamate	$NH_4OSO_2NH_2$

1.5 Prevalence and Use

Ammonia is a widely used chemical, being involved in the manufacture of fertilizers, nitric acid, explosives, and synthetic fibers. It is also used in refrigeration (8.8). Occupations with the potential for exposure to ammonia include the following (8.7):

Amine workers	Fertilizer workers
Ammonia workers	Glass cleaners
Ammonium salt makers	Maintenance workers (janitors)
Aniline makers	Manure handlers
Case hardeners	Nitric acid makers
Chemical laboratory workers	Organic chemical synthesizers
Chemical manufacturers	Petroleum refinery workers
Coal tar workers	Refrigeration workers
Color makers	Rocket fuel makers

Compressed gas workers	Sewer workers
Cyanide makers	Soda ash makers
Dye makers	Solvay process workers
Explosive makers	Tanners
Farmers	Urea makers

1.6 Toxicology (8.7, 8.9, 8.10)

Note:	Information contained within this section is a synopsis of present knowledge of the physiological effects of ammonia and is not intended to be used as a basis for OSHA policy.

Ammonia forms a strong alkaline solution in water, and the high solubility and strong alkalinity make it especially irritating to the upper respiratory system. Exposure to ammonia can occur not only from the vapor but also from the liquid and from concentrated aqueous solutions. Depending upon the exposure, symptoms can range from mild upper respiratory irritation to inflammatory processes of the entire respiratory tract with complications of pulmonary edema and bronchopneumonia. Symptoms may also include hoarseness and tightness in the throat. The odor threshold for ammonia varies among the reports received; 50 ppm is known to produce a strong odor. Brief exposure to 100 ppm increases nasal air flow resistance, possibly from vascular congestion, edema and increased mucus secretion. Mild irritation of the eyes, nose and throat is produced by 50 ppm but not by 25 ppm. Acclimation appears to develop to 50 ppm within one week, and to 100 ppm within 2 to 3 weeks of repeated exposure. Volunteers exposed to 500 ppm for 30 minutes experienced hyperventilation and an increase in respiratory rate. Exposure to 1,000 ppm produced immediate coughing. Exposures to 700 to 1,700 ppm can be incapacitating due to extreme lacrimation and coughing. The eyes, skin and respiratory tract may be severely inflamed. Massive accidental exposure can be quickly fatal; autopsies of individuals who have died from exposure have indicated severe damage at every level of the respiratory system, including edema and hemorrhage. Skin burns from exposure to liquid ammonia can also occur. Ammonia is irritating to the eyes; failure to irrigate the eyes with a considerable amount of water following heavy exposure may lead to blindness.

2. Range, Detection Limit and Sensitivity (8.11)

2.1 This method was validated over the concentration range of 30.7 to 101.8 ppm. Air volumes of about 21 L and flow rates of about 0.1 L/min were used. The average sampling time was 210 min.

2.2 The qualitative detection limit was 0.2 µg/mL or 10.0 µg (as NH_3) when using a 50-mL solution volume. This corresponds to 0.60 ppm NH_3 for a 24-L air volume. The quantitative detection limit was 0.50 µg/mL or 25 µg (as NH_3) when using a 50-mL solution volume. This corresponds to 1.5 ppm NH_3 for a 24-L air volume. A 50-µL sample loop and a 30 microsiemens detector setting were used for both IC detection limit determinations.2.3 The sensitivity of the analytical method, when using the instrumentation specified in Section 6.2, was calculated from the slope of a linear working range curve (1 to 10 µg/mL ammonium ion). The sensitivity was 12,380 area counts per 1 µg/mL ammonium ion (a Dionex AutoIon 400 data reduction system was used). Data manipulation was also performed using a Hewlett-Packard 3357 Laboratory Automation System. The sensitivity for this system was 361,000 area counts per 1 µg/mL ammonium ion (1 area count = 0.25 microvolt-second for the Hewlett-Packard system).

3. Method Performance (8.11)

Test results are based on samples collected from an in-house dynamic generation system at flow rates of approximately 0.1 L/min and sampling times of 180 to 240 min. Exceptions are noted below.

3.1 The pooled coefficient of variation (CV_T) for samples taken in the range of 30.7 to 101.8 ppm was 0.050. The method exhibited slight negative bias (-0.009). overall error was within acceptable limits at ±10.9%.

3.2 The collection efficiency at about 2 times the PEL was 100%.

3.3 Breakthrough tests were performed at a concentration of 258 ppm, 50% RH, and 25°C. Breakthrough of ammonia into backup sections of sorbent was undetectable. Samples were collected for 335 min.

3.4 Samples can be stored at ambient (20 to 25°C) laboratory conditions for at least 29 days. The mean recovery of samples analyzed after 29 days was within 5% of the mean recovery of samples analyzed after 1 day of storage. Samples were stored in an office desk.

3.5 Sampling tubes stored 11 months before use gave satisfactory results during validation experiments.

4. Interferences

4.1 When other compounds are known or suspected to be present in the air, such information should be transmitted with the sample.

4.2 Any compound having the same retention time as the ammonium ion, is an interference. The following compounds were noted as potential interferences with ammonium ion when using the equipment and conditions stated in Section 6:

Methyl- and dimethylamine, mono- and diethanolamine, iso- and propanolamine.

4.2.1 Methylamine and ammonium are not separated well in a 1:1 mixture (Figure 1a and 1b). Dimethylamine and ammonium in a 1:1 mixture show better resolution (Figure 1c).

1) Both mixtures displayed diminished peak areas for the ammonium ion; however} ammonium peak heights were similar to the 10 µg/mL standard shown in Figure 1a. If an interference of this type is present, peak heights can be used for calculations instead of peak areas.
2) An alternate eluent (0.012 M HCl) offered sufficient resolution between ammonia and methyl- or dimethylamine (Figure 1d and 1e). This eluent can be used for confirmation if necessary.

4.2.2 A peak in the same vicinity as ammonia was noted when a dilute monoethanolamine (MEA) solution was analyzed (see Figure 1f). The detector response for MEA is about one-half that seen for ammonia at a concentration of approximately 10 µg/mL (Figure 1a and 1f). Separation of ammonium and MEA was not noted when a 1:1 mixture (10 µg/mL for each) was analyzed when using either the recommended or the alternate eluent.

(Note:	The MEA used for this study contained trace contaminants as shown by peaks 1 and 3 in Figure 1f. These peaks probably represent trace amounts of sodium and potassium ions, respectively.)

4.2.3 Diethanolamine (DEA) also produces a response; however, this response is only noticeable at very large concentrations. A concentration of 10 µg/mL DEA did not produce a measurable peak.

4.2.4 Propanolamine and isopropanolamine elute at approximately the same time and with a similar response as MEA.4.2.5 If necessary, the presence of ammonia, methyl- or dimethylamine, MEA, isopropanolamine or propanolamine can be confirmed using mobile phase ion chromatography (8.6).

4.3 Contaminant cations, such as Na^+ and K^+, do not interfere when using the conditions and instrumentation specified. When using the conditions described in Section 6, peak retention times of individual 10 µg/mL solutions of various analytes were:

Analyte	Retention Time (min)
urea	no response
methanol	no response
diisopropanolamine	no response
triisopropanolamine	no response
diethanolamine (10 µg/mL)	no response
triethanolamine	no response
sodium	3.28
monoethanolamine	3.67
isopropanolamine	3.68
ammonium	3.70
propanolamine	3.77
diethanolamine (1,000 µg/mL)	3.80
methylamine	4.08
dimethylamine	4.17
ethylamine	4.35
diethylamine	4.77
potassium	4.83

Note: The listing above is for information only. The majority of these analytes will most likely not be present when sampling for ammonia. Retention times may vary slightly.

4.4 Interferences may be minimized by changing the eluent, eluent concentration or pump flow rate.4.5 Complete separation and quantitation of low molecular weight alkyl amines as well as the alcoholic amines can be achieved using mobile phase ion chromatography (8.6) or alternate sampling and analytical methods (8.12, 8.13).4.6 alternate ISE or calorimetric methods can also be used (8.1, 8.2); however, interferences are a significant problem for both methods.

4.7 Ammonium salts present as dust would interfere; however, this material should be collected in the glass wool plug preceding the collecting medium. A prefilter consisting of a mixed-cellulose ester filter in a polystyrene cassette can also be used if a large amount of particulate is present in the atmosphere. Preliminary tests comparing sampling tubes with and without a prefilter did not indicate a significant difference in recoveries; therefore, ammonia did not react with the prefilter components. Tests were conducted using a dynamic test atmosphere of 184 ppm NH_3 at 50% RH and 25°C.

5. Sampling

5.1 Equipment - Ammonia Sampling

5.1.1 Personal sampling pumps capable of sampling within ±5% of the recommended flow rate of 0.1 L/min.

5.1.2 Carbon bead, 20/30 mesh (Kureha Chemical Industry Co., 420 Lexington Ave., Suite 1742, NY, 10170, phone no. 212-867-7040).

5.1.3 Sampling tubes which contain an adsorbing section consisting of carbon beads treated with H_2SO_4. Tubes are commercially available, but may also be easily prepared (**Caution:** Sulfuric acid can cause severe burns. Wear protective gloves, labcoat and eyewear when using H_2SO_4).

1. The commercially available tube consists of two sections; a 500-mg carbon bead front and a 250-mg backup section (ORBO-77 Tubes, cat. no. 582-12, Supelco Inc., Bellefonte, PA or SKC cat. no. 226-29, SKC, Eighty Four, PA).

2. Ammonia collection tubes may be prepared according to the method of Bishop, Belkin and Gaffney (8.3). The following is a variation of this method: Thirty-one sampling tubes can be prepared using 23 g of carbon beads. The beads are placed in a beaker, rinsed five times with 0.01 N H_2SO_4 and then five times with DI H_2O . Sufficient concentrated H_2SO_4 (1.2 g of acid for 23 g of beads) is added so the final product, when dried, will consist of 5% acid by weight. Enough DI H_2O to just cover the beads is also added and the con ents are mixed. The product is dried at 110°C overnight in a drying oven. The beads are mixed and then packed into glass tubes, 10 cm × 8 mm o.d. × 6 mm id. The front absorbing section contains 500 mg and the backup section 250 mg of carbon beads. Each section is held in place by glass wool plugs. The tubes are capped with plastic end caps or are fire sealed.

5.1.4 A stopwatch and bubble tube or meter are used to calibrate the pumps. A blank sampling tube or device is placed in-line during flow rate calibration.

5.1.5 Various lengths of flexible tubing are used to connect the sampling tubes to the pumps.5.1.6 Mixed-cellulose ester filters and polystyrene cassettes can be used as prefilters if particulate are a potential problem. See Section 5.3 for further details.

5.2 Sampling Procedure - Ammonia

5.2.1 Calibrate the sampling pumps to the recommended flow rate of 0.1 L/min for TWA determinations or to 0.5 L/min for STEL measurements.

5.2.2 Connect the sampling tube to the pump such that air enters the larger (500 mg) section first.

5.2.3 Place the sampling tube in the breathing zone of the employee.

5.2.4 Sample with the pre-calibrated pump at the listed flow rate and sampling time. The recommended sampling time is 4-h for TWA assessments, giving a total air volume of about 24-L. For STEL determinations, sample for 15 min.

5.2.5 Prepare one sampling tube as a blank sample. Treat this tube the same as the samples except that no air is drawn through it.

5.2.6 Place plastic end caps on each tube after sampling. Attach an OSHA seal around each tube to secure the end caps. Send the samples along with a blank sample to the laboratory with the OSHA 91A paperwork requesting ammonia analysis.

5.2.7 Bulks can also be submitted for analysis. Ship bulk samples separately from air samples. They should be accompanied by Material Safety Data Sheets if available. Check current shipping restrictions and ship laboratory by the appropriate method.

5.3 Sampling for Ammonium Chloride or Ammonium Sulfamate

The following equipment is used:

1. Mixed-cellulose ester (MCE) filters (0.8 µm pore size), cellulose backup pads, and cassettes, 37-mm diameter (part no. MAWP 037 AO, Millipore Corp., Bedford, MA).

2. Gel bands (Omega Specialty Instrument Co., Chelmsford, MA) for sealing cassettes.

3. Calibrated sampling pumps - 0.1 to 2 L/min flow rate.

Connect the MCE filter/cassette assembly to a calibrated sampling pump and collect samples at a flow rate of about 2 L/min.

Note: If the filters are to be used as prefilters, attach the cassette to the CISA sampling tube with a minimum amount of tubing, and attach the free end of the CISA tube to the sampling pump. Sample at a flow rate of 0.1 L/min if a prefilter is used.

Sample for at least 15 min for STEL measurements and up to 8 h for TWA determinations. After sampling, seal and submit the samples to the laboratory. Request analysis for ammonium sulfamate or ammonium chloride.

6. Analysis

6.1 Precautions

6.1.1 Refer to instrument and standard operating procedure (SOP) manuals (8.14) for proper operation.

6.1.2 Observe laboratory safety regulations and practices. **Caution:** Sulfuric or hydrochloric acid can cause severe burns. Wear protective gloves, labcoat and eyewear when using these acids.

6.2 Equipment

6.2.1 Ion chromatography (Model 2010i, Dionex, Sunnyvale, CA) equipped with a conductivity detector.

6.2.2 Automatic sampler (Model AS-1, Dionex) and sample vials (0.5 mL).

6.2.3 Data processing system (AutoIon 400 System, Dionex).

6.2.4 Printer.

6.2.5 Cation separator column (Model HPIC-CS3, Dionex).

6.2.6 Cation guard column (Model HPIC-CG3, Dionex).

6.2.7 Cation micromembrane suppressor (Model CMMS-1 suppressor, Dionex).

6.2.8 Disposable syringes (1 mL) and prefilters.

(Note: Some prefilters are not cation- or anion-free. Tests should be done with blank solutions first to determine suitability for the analyte being determined).

6.2.9 Polyethylene scintillation vials (20 mL) with polyethylene cap liners (Part No. 58515, Kimble, Toledo, OH).

6.2.10 Miscellaneous volumetric glassware: Beakers, graduated cylinders, beakers, and volumetric flasks (0.25 to 4 L).

6.2.11 Analytical balance (0.01 mg).

6.3 Reagents - All chemicals should be reagent grade or better

6.3.1 Deionized water (DI H_2O) with a specific conductance of less than 10 microsiemens.

6.3.2 Hydrochloric acid (HCl) solution (1 N):

Dilute 166 mL of concentrated HCl to 2.0 L with DI H_2O.

6.3.3 Strong eluent (48 mM HCl, 4 mM DAP-HCl, 4 mM L-histidine -HCl): Weigh 0.560 g 2,3-diaminopropionic acid monohydrochloride (DAP-HCl) and 0.840 g L-histidine monohydrochloride monohydrate and then place in a 1-L volumetric flask. Add 48 mL of 1 N HCl. Dilute to volume with DI H_2O. Mix thoroughly. Prepare monthly.

6.3.4 Weak eluent (12 mM HCl, 0.25 mM DAP-HCl, 0.25 mM L-histidine-HCl):

Note: Prepare a new solution for each analysis. Aged solutions of weak eluent tend to lose buffering capacity. Chromatographic dips in the vicinity of the ammonium peak have been noted using aged eluent and may lead to erroneous results. These dips only occur with samples (which contain a small amount of sulfuric acid) and do not occur with standards (prepared with DI H_2O).

Dilute 252 mL of strong eluent and 36 IRL of 1 N HCl to 4.0 L with DI H_2O. Mix thoroughly.

6.3.5 alternate eluent (12 mM HCl): This eluent is only used if potentially resolvable interferences are present (See Section 4.2.1 for further information). Dilute 48 mL of 1 N HCl to 4.0 L with DI H_2O. Prepare a new solution for each analysis.

6.3.6 Regeneration solution [0.04 N tetramethylammonium hydroxide $(CH_3)_4NOH$ (TMAOH)] (Note: The purity of the reagent must be considered when preparing the 0.04 N TMAOH solution.): Commercially prepared solutions of 25% TMAOH can be used (25% TMAOH, cat. no. 33,163-5, Aldrich Chemical Co., Milwaukee, WI). Dilute 57.4 mL of 25% TMAOH to 4 L with DI H_2O. An alternative preparation is to dissolve 29.00 g of tetramethylammonium hydroxide pentahydrate $[(CH_3)_4NOH \cdot 5H_2O]$ in 4.0 L of DI H_2O.

6.3.7 The eluent used with CSRS suppressor, IonPac CS12 column, and CG12 guard column is 20 mM methane sulfonic acid (CH_3SO_3H) solution. Dilute 2.6 mL methane sulfonic acid to 2.0 L with DI H_2O (Methane sulfonic acid, cat. no. M860-6, Aldrich Chemical Co., Milwaukee, WI).

6.3.8 Sulfuric acid solution (0.1 N): Dilute 5.6 mL of concentrated H_2SO_4 to 2.0 L with DI H_2O.

6.3.9 Ammonia stock standard (1,000 µg/mL ammonia): Dissolve 3.141 g of ammonium chloride in 0.1 N H_2SO_4 and dilute to the mark in a 1-L volumetric flask. Prepare every month.

6.3.10 Ammonia standard (100 µg/mL). Dilute 50 mL of the 1,000 µg/mL ammonia stock standard to 500 mL with DI H_2O. Prepare weekly.

6.3.11 Ammonia standard (10 µg/mL). Dilute 50 mL of the 100 µg/mL ammonia stock standard to 500 mL with DI H_2O. Prepare weekly.

6.4 Working Standard Preparation

6.4.1 Ammonia working standards may be prepared weekly in the ranges specified:

Working STD (µg/mL)	Standard Solution (µg/mL)	Aliquot (mL)	Final Vol. (mL)
1	10	10	100
2	10	20	100
5	100	5	100
10	10	*	*
15	100	30	200
20	100	20	100

* Already prepared in Section 6.3

6.4.2 Pipette appropriate aliquots from standard solutions prepared in Section 6.3 into volumetric flasks of the final volumes specified. Dilute to volume with DI H_2O.

6.4.3 Pipette a 0.5- to 0.6-mL portion of each standard solution into separate automatic sampler vials. Place a 0.5-mL filter cap into each vial. The large exposed filter portion of the cap should face the standard solution. Also prepare a reagent blank from the DI H_2O used for standard preparation.

6.5 Sample Preparation - CISA Samples

Note: For the CISA samples, always use a final solution volume **>**25 mL.

6.5.1 Carefully remove and discard the glass wool plugs from the sample tubes, making sure that no sorbent is lost in the process. Transfer each sorbent section into individual polyethylene vials.

6.5.2 Add 10 mL of DI H_2O to each vial, cover vials with polyethylene lined caps and then shake vigorously for about 30 s. Allow the solutions to settle for at least 1 h.

6.5.3 Quantitatively transfer each front section desorption solution to individual 25- or 50-mL volumetric flasks.

6.5.4 Rinse the beads in the vial with additional portions of DI H_2O and also transfer this rinse to the flask. Take care so the beads are not transferred to the flask.

6.5.5 Dilute to volume with DI H_2O. Also transfer each backup section resorption solution to individual 25- or 50-mL volumetric flasks and dilute to volume.

6.5.6 An alternate method of resorption and dilution is: Place the beads into 25- or 50-mL volumetric flasks. Measure the appropriate amount of DI H_2O using a pipette or graduated cylinder and add this to the carbon beads.

6.5.7 If the sample solutions contain particulate, remove the particles using a prefilter and syringe. Fill the 0.5-mL automatic sampler vials with sample solutions and push a filtercap into each vial.

6.5.8 Load the automatic sampler with labeled samples, standards and blanks.

6.6 Sample Preparation - Ammonium Chloride Fume or Ammonium Sulfamate

6.6.1 Open the filter cassette, carefully remove the sample filter with forceps, and place in a scintillation vial. If the cassette contains loose dust, carefully rinse the dust into the vial with DI H_2O. If necessary, wipe out the dust with a clean MCE filter and place this filter in the vial. If the backup pad appears to be discolored, it may be due to leakage of air around the filter during sampling. In these cases, the pad should also be prepared and analyzed. Place the backup pad in a separate vial. Also prepare a blank backup pad.

6.6.2 Add 10 mL of DI H_2O to each scintillation vial. Allow to sit for at least 1 h with occasional agitation of the solution and filter. Proceed with the analysis as described in Sections 6.5.7-6.5.8 and 6.7

6.7 Analytical Procedure

6.7.1 Set up the ion chromatography in accordance with the SOP (8.14) or instrument manuals.

Typical operating conditions for a Dionex 2010i with an automatic sampler are listed below:

Ion chromatograph	
Eluent (Section 6.3.4):	DAP-histidine-HCl
Eluent conductivity:	approximately 7 microsiemens
Regenerant flow:	2 to 3 mL/min (0.04 N TMAOH)
Sample injection loop:	50 µL
Pump	
Pump pressure:	approximately 550 psi
Flow rate:	1 mL/min
Chromatogram	
Run time:	5 min
Average peak retention time:	3.7 to 3.9 min

Note:	If the alternate eluent is used, allow a longer period of time for the ion chromatography to equilibrate (2 to 3 h). The retention time of the ammonium ion will be much longer with the alternate eluent.

6.7.2 If an ion chromatography is not available, the sample solutions may be acidified with H_2SO_4 to 0.1 N and analyzed with an ammonia ISE as described in Method No. ID-164 (8.1).

7. Calculations

7.1 After the analysis is completed, peak areas and heights can be retrieved using a variety of methods or programs (8.14). Hard copies of chromatograms, which list peak heights and areas, can be obtained from a printer. An example chromatogram containing 3 µg/mL sodium, 20 µg/mL ammonium, and 10 µg/mL potassium ions is shown in Figure 2.

7.2 prepare a concentration-response curve by plotting the concentration of the standards in µg/mL (or µg/sample if the same solution volumes are used for samples and standards) versus peak areas or peak heights. Blank correct each sample section (sample and blank solution volumes should be the same). Add the backup section results to the front section results for each tube.

7.3 The concentration of ammonia in each air sample is expressed in ppm. The equation is:

$$\text{ppm } NH_3 = \frac{\text{molar volume} \times \mu\text{g/mL } NH_3 \times \text{solution volume (mL)}}{\text{formula weight} \times \text{air volume (L)}}$$

Where:

Molar Volume = 24.46 (25°C and 760 mm Hg)

Formula Weight (NH_3) = 17.03

µg/mL NH_3 = Blank corrected value from Section 7.2

7.4 For ammonium chloride fume or ammonium sulfamate:

$$\text{mg/m}^3 \text{ analyte} = \frac{\mu\text{g/mL } NH_3 \times \text{solution volume (mL)} \times GF}{\text{air volume}}$$

Where:

µg/mL NH_3 = Blank corrected value from Curve

GF = Gravimetric Factor:

Ammonium chloride (NH_4Cl) = 3.14

Ammonium sulfamate ($NH_4OSO_2NH_2$) = 6.70

7.5 Report CISA results to the industrial hygienist as ppm ammonia. Report ammonium chloride or ammonium sulfamate results as mg/m^3. Ammonium chloride or sulfamate results are based on the analysis of the ammonium ion; other ammonium salts present in the air during sampling may be a positive interference.

8. References

8.1 **Occupational Safety and Health Administration Analytical Laboratory: OSHA Analytical Methods Manual** (OSHA-SLCAL Method No. ID-164). Cincinnati, OH: American Conference of Governmental Industrial Hygienists (Pub. No. ISBN: 0-936712-66-X), 1985. v8.2 **Occupational Safety and Health Administration Analytical Laboratory: OSHA Manual of Analytical Methods** edited by R.G. Adler (OSHA-SLCAL Method No. VI-1). Salt Lake City, UT. 1977.

8.3 **Bishop, R.W., F. Belkin and R. Gaffney:** Evaluation of a New Ammonia Sampling and Analytical Procedure. **Am. Ind. Hyg. Assoc. J. 47**: 135-137 (1986).

8.4 **National Institute for Occupational Safety and Health: NIOSH Manual of Analytical Methods, 2nd ed., Vol. 1** (HEW/NIOSH Pub. No. 77-157-A). Cincinnati, OH: National Institute for Occupational Safety and Health, 1977.

8.5 **Occupational Safety and Health Administration Analytical Laboratory: Ammonia Detector Tubes** (PE-7). Salt Lake City, UT. 1987.

8.6 **Dionex Corp.: Basic Ion Chromatography**. Sunnyvale, CA: Dionex Corp., 1983.

8.7 **National Institute for Occupational Safety and Health: Criteria for a Recommended Standard . ..Occupational Exposure to Ammonia)** (HEW/NIOSH Pub. No. 74-136). Cincinnati, OH: National Institute for Occupational Safety and Health, 1974.

8.8 **Windholz, M., S. Budavari, R.F. Blumetti, and E.S. Otterbein, ed.: The Merck Index**. 10th ed. Rahway, NJ: Merck & Co., 1983. p. 498.

8.9 **Proctor, N.H. and J.P. Hughes: Chemical Hazards of the Workplace**. Philadelphia, PA: J.B. Lippincott Company, 1978. pp. 101-102.

8.10 **Frank, R.:** Acute and Chronic Respiratory Effects of Exposure to Inhaled Toxic Agents. In **Occupational Respiratory Diseases**, edited by J.A. Merchant. Washington, D.C.: U.S. Government Printing office, 1986. pp. 573-576.

8.11 **Occupational Safety and Health Administration Technical Center: Ammonia Backup Data Report (ID-188)**. Salt Lake City, UT, Revised 1991.

8.12 **Occupational Safety and Health Administration Analytical Laboratory: OSHA Analytical Methods Manual** (OSHA-SLCAL Method Nos. 34, 36, 40, 41). Cincinnati, OH: American Conference of Governmental Industrial Hygienists (ACGIH Publ. No. ISBN: 0-936712-66-X), 1985.

8.13 **Occupational Safety and Health Administration Analytical Laboratory: Ethanolamine and Diethanolamine** (OSHA-SLCAL Stopgap Method). Salt Lake City, UT. 1987 (unpublished).

8.14 **Occupational Safety and Health Administration Technical Center: Standard Operating Procedure-Ion Chromatography.** Salt Lake City, UT. In progress (unpublished).

Interference Chromatograms

PEAK NUM	RET TIME	CONC in ppm	AREA	height
1	3.18		2.445e+003	239
2	3.70		1.122e+003	6801

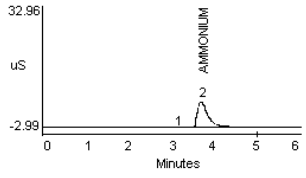

Figure 1a

PEAK NUM	RET TIME	CONC in ppm	AREA	height
1	3.20		3.912e+003	345
2	3.73		7.910e+004	6081
3	4.00		1.936e+005	12221

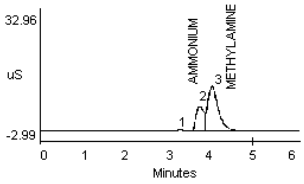

Figure 1b

PEAK NUM	RET TIME	CONC in ppm	AREA	height
1	3.20		2.746e+003	276
2	3.72		9.505e+004	6867
3	4.08		1.558e+003	9673

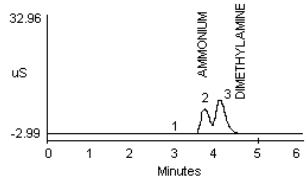

Figure 1c

PEAK NUM	RET TIME	CONC in ppm	AREA
1	13.52		1.366e+003
2	16.57		1.758e+005

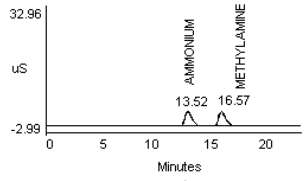

Figure 1d

PEAK NUM	RET TIME	CONC in ppm	AREA	height	
1	13.45		1.477e+005	3838	1
2	19.23		1.475e+005	2854	1

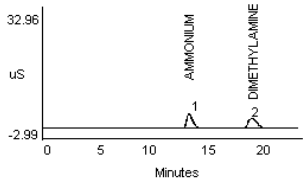

Figure 1e

PEAK NUM	RET TIME	CONC in ppm	AREA	height
1	3.18		2.260e+004	2021
2	3.67		4.183e+004	2949
3	4.72		8.419e+003	560

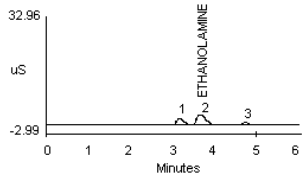

Figure 1f

Figure 1

All identified species are 10 µg/mL

Ion Chromatogram of Sodium, Ammonium, and Potassium Ions

PEAK NUM	RET TIME	CONC in ppm	AREA	height
1	3.22		8.906e+004	7972
2	3.73		1.775e+005	10273
3	4.70		1.940e+005	11514

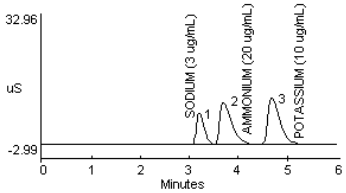

Figure 2

B2.b. Ammonia Sampling Instructions

Columbia Analytical Services INC.

An Employee - Owned Company

AMMONIA

Ammonia is an odorous contaminant of concern for a wide variety of facilities including landfills (product of decomposition); wastewater treatment plants (in untreated sewage); composting operations (product of both aerobic and anaerobic decomposition); and hog, dairy, and poultry farms (in animal waste). Since ammonia is often used as a household glass & surface cleaner, most people are familiar with its odor; thus, the unique and pungent aroma can usually be detected by the human olfactory system at low ppmV concentrations. At higher ppmV concentrations, ammonia can cause serious health damage, irritating and/or burning nasal passages and lungs.

Collection of airborne ammonia may follow the OSHA ID-188 method, which uses sulfuric acid coated Anasorb-747 (carbon bead) tubes and a personal sampling pump for collection; this means of sample collection is much easier and safer than the traditional collection technique of sulfuric acid solution impingers. Analysis may follow the OSHA-ID 164 analysis, which utilizes an ion specific electrode (ISE) to detect ammonia.

The impact of airborne ammonia is a significant concern in agricultural markets.

EQUIPMENT

1. Air sampling pump* capable of sampling at the desired flow rate/duration with the sampling medium in-line.
2. Airflow calibrator* (bubble meter, rotometer, Bios DryCal flow meter, etc.)
3. Sorbent tube – commercially available from SKC *(catalog number 226-29)*, laboratory will provide upon request. Tubes may be stored at ambient temperature prior to use. After sampling, samples may be stored and shipped at ambient temperature to the laboratory.
4. Field blank - A field blank tube should be included in the sampling event. Field blanks should be subjected to exactly the same handling as the samples (open, seal, and transport), but no air is drawn through them.

** CAS does not provide this equipment; contact your local equipment rental company or call the laboratory for help finding vendors.*

RELATED CAS ODOR & LANDFILL SERVICES:

Reduced Sulfur Compounds via ASTM D5504

Amines via CAS AQL Method 101

Carboxylic Acids via CAS AQL Method 102

Speciated VOCs via EPA TO-15 and/or EPA TO-17

Methane/Total Gaseous Non-Methane Hydrocarbons via EPA 25C

Fixed Gases via EPA 3C

BTU Heat Content / CHONS via ASTM D3588

AMMONIA REPORTING LIMIT (ppmV)

Flow Rate (L/MIN)	Duration 15 Min	30 Min	1 Hr	2 Hrs	3 Hrs	4 Hrs
0.1	9.6	4.8	2.4	1.2	0.80	0.60
0.3	3.2	1.6	0.80	0.40	0.27	0.20
0.5	1.9	0.96	0.48	0.24	0.16	0.12

Reporting Limit = 0.01 mg/tube

Please call the laboratory with questions regarding the effect sample volume has on reporting limits.

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SAMPLING GUIDE

Sampling Flow Rate: 0.10 - 0.50 L/min

Air Volume: 7.5 - 24L for ambient and indoor air.

Sample Time: 15 minutes - 4 hours

If sampling pump <u>is not received</u> pre-calibrated:

Using an airflow calibrator, calibrate pump with representative media inline, following directions provided from vendor. Request a calibration tube to be provided from the lab. (***Please do not use a sample tube.***)

If sampling pump <u>is received</u> pre-calibrated:

1. Remove the sample tubes from the shipping container.
2. Please DO NOT write/scratch any additional information on the tube.
3. The airflow direction will be printed on the SKC tube in the form of a directional arrow. Ensure that the arrow points towards the pump.
4. Clip both ends of the SKC tube to allow air flow to pass through the tube. Place the end of the tube into the tubing attached to the sampling pump, ensuring the arrow is still pointing towards the pump.
5. Set up the sampling tube in the sampling location.
6. Turn the pump on and note the starting time and date.
7. If collecting a field blank, uncap the field blank tube on both ends to expose it to field conditions, and then immediately recap the tube with the red end caps provided. Place the field blank tube aside.
8. Sample at a known flow rate for the recommended period of time.
9. At the end of the sampling period, retrieve the sampler, turn the pump off and record the final sampling time.
10. Recap all samples with the red end caps provided. Label the tubes with the sampling information (sample identification, sample date, etc.) by affixing a label to the outside of the tube and/or placing the tube inside a labeled, small Ziploc bag.

Airborne ammonia can also be prevalent at landfill sites.

STORAGE & SHIPPING INSTRUCTIONS

- Carefully pack sample tubes and field blank in a cooler or small box. Be sure to include all pertinent information (sample identification, sampling date, time, sample volume, etc.) on the Chain of Custody form submitted with the samples.
- Ship the cooler to the laboratory using an overnight courier service (FedEx, UPS, etc.). If unable to ship the samples back to the laboratory on the same day of sampling, store the samples in sealed containers away from any potential sources of contamination.

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B3. SOP for Determination of Hydrogen, Carbon Monoxide, Carbon Dioxide, Nitrogen, Methane, and Oxygen using Gas Chromatography with Thermal Conductivity Detection (TCD) in Accordance or Modification of EPA Method 3C or ASTM D 1946

STANDARD OPERATING PROCEDURE

for

Determination of Hydrogen, Carbon Monoxide, Carbon Dioxide, Nitrogen, Methane, and Oxygen using Gas Chromatography with Thermal Conductivity Detection (TCD) in Accordance or Modification of EPA Method 3C or ASTM D 1946

SOP Code: VOA-EPA3C

Revision: 9

Effective Date: 10-14-11

Approved by:

Wade Henton – Team Leader (Volatile GCDepartment) — Date: 10/7/11

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Annual review of this SOP has been performed and the SOP still reflects current practice.

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Standard Operating Procedure for Determination of Hydrogen, Carbon Monoxide, Carbon Dioxide, Nitrogen, Methane, and Oxygen using Gas Chromatography with Thermal Conductivity Detection (TCD) in Accordance or Modification of EPA Method 3C or ASTM D 1946

1.0 SCOPE AND APPLICATION

The referenced method (EPA Method 3C) was written for the analysis of carbon dioxide, methane, nitrogen and oxygen, in municipal solid-waste landfill gas and other stationary sources but is easily modified for the gas chromatographic method determination of hydrogen and carbon monoxide. In contrast, the practice ASTM D 1946 covers the determination of the chemical composition of reformed gases and similar gaseous mixtures containing each of these six components.

This method is appropriate for quantifying target analyte gases depending on the concentration of the samples from approximately 500 ppmv to high percent values. The number of samples, which may be analyzed in one eight hour day, is approximately twenty. The reporting limits for these analytes are listed in Attachment D of this standard operating procedure.

2.0 METHOD SUMMARY

The EPA Method 3C was written for use with backfilled summa canisters but is easily modified for samples collected as vapor in Tedlar bags, steel tanks, summa or other specially prepared canisters. In contrast, the ASTM method does not specify a requirement for the sampling container.

An aliquot is drawn from the sampling container using a sample loop and injected onto a packed chromatographic column where the analytes are separated and measured using a thermal conductivity detector (TCD). Samples are analyzed in duplicate for EPA Method 3C, but a modification may be made which entails a single injection per submitted field sample. However, results from samples analyzed per ASTM D 1946 are obtained using a single injection technique.

Note: Refer to **Sections 13.9 and 20.0** for the list of reporting modifications for these methods.

3.0 DEFINITIONS

3.1 Analytical Sequence

The analytical sequence describes exactly how the field and QC samples in an analytical batch are to be analyzed.

3.2 Field Sample

A sample collected and delivered to the laboratory for analysis.

3.3 Batch QC

The QC samples that are analyzed in an analytical batch of field samples and includes the Method Blank (MB), Laboratory Control Sample (LCS) or Laboratory Duplicate (LD).

3.4 Calibration Standard (Initial Calibration – ICAL)

A calibration standard of a known concentration containing desired analyte(s) prepared from a primary standard, which is, in turn, prepared from a stock standard material. A calibration standard is injected at varying volumes and used to calibrate the response of the measurement system with respect to analyte concentration.

3.5 Initial Calibration Verification (ICV) Standard

An ICV is a standard that is obtained from a source other than the source for the calibration standards and is analyzed after the measurement system is calibrated, but prior to sample analysis in order to verify the initial calibration of the measurement system.

3.6 Method Blank (MB)

An analyte-free matrix, which is carried through the entire analytical process. It is used to evaluate the process for contamination from the laboratory.

3.7 Laboratory Control Sample (LCS)

An LCS is a standard that is obtained from a source other than the source for the continuing calibration verification standard (CCV). The percent recovery of the analyte(s) in the LCS is used to assess method performance.

3.8 External Standard Calibration

External standard calibration involves comparison of instrument responses from the sample to the responses from the target compounds in the calibration standards. Sample peak areas or peak heights are compared to peak areas or peak heights of the standards.

3.9 Analytical Batch

A group of samples which behave similarly with respect to the sampling or the test procedures being employed and are processed as a unit using the sample lots of reagents and with the manipulations common to each sample within the same time period or in continuous sequential time periods. In an analytical batch of samples, the time period is 24 hours or up to twenty sample injections, whichever comes first of continuous operation without interruption.

3.10 Continuing Calibration Verification (CCV) Standard

A continuing calibration verification standard is a midrange calibration standard that is analyzed periodically to verify the continuing calibration of the measurement system.

3.11 Precision

Precision of a method is how close results are to one another, and is usually expressed by measures such as standard deviation, which describe the spread of results.

3.12 Bias

The bias of a method is an expression of how close the mean of a set of results (produced by the method) is to the true value.

3.13 Manual Integration

This term applies to a data file in which setpoints have been changed and reintegration has occurred under the changed setpoints; baselines have been adjusted; peak integration start and stop "ticks" have been changed; peak area, or peak height, are changed after the time of data collection and data file generation.

3.14 Ambient Air

Ambient air within the laboratory which is sampled and analyzed once per batch to assess injector performance.

3.15 Limit of Detection (LOD)

The smallest amount or concentration of a substance that must be present in a sample in order to be detected at a high level of confidence (99%). At the LOD, the false negative rate (Type II error) is 1%. (DoD Clarification). For consistency purposes, the LOD may be referred to as the MDL once it is reported; however, full verification will be on file in the laboratory per the procedures detailed in this document.

3.16 Limit of Quantitation (LOQ)

The lowest concentration that produces a quantitative result within specified limits of precision and bias. For DoD projects, the LOQ shall be set at or above the concentration of the lowest initial calibration standard. (DoD Clarification). For consistency purposes and since the LOQ and MRL are equivalent with regards to laboratory procedure, the LOQ will be referred to as the MRL in this document and once it is reported. Full verification will be on file in the laboratory per the procedures detailed in the document.

3.17 Detection Limit (DL) / Method Detection Limit (MDL)

The smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration at the 99% level of confidence. At the DL, the false positive rate (Type 1 error) is 1%. (DoD Clarification). For consistency purposes, the DL may be referred to as MDL. Also, as far as reporting is concerned the MDL will be raised up (where necessary) to the verified LOD per the procedures defined in this document and reported accordingly.

4.0 INTERFERENCES

4.1 Contamination

Dry ambient air at sea level contains 78.08% Nitrogen, 20.95% Oxygen, 0.93% Argon, and approximately 0.033% Carbon Dioxide by volume. Precautions must be taken to prevent intrusion of ambient air into the analytical system and the sampling containers.

4.1.1 Contamination in the Sample Care must be taken to prevent ambient air intrusion into the sample container during canister pressurization and laboratory analysis. When using adapters and fittings the dead volume should be evacuated and replaced with the sample gas prior to sampling from the container.

4.1.2 Carrier Gas Contamination To prevent system contamination, UHP/ZERO grade helium (99.999% purity) is used as the carrier gas. Also, a purifier and an oxygen trap are incorporated into the analytical system as additional insurance against possible contamination.

4.2 Peak Separation

Since the TCD exhibits universal responses and detects all gas components except the carrier (helium, in this case), the appropriate temperature program, column flow rates and column packing must be used in order to separate all of the permanent gases with an exception of argon

4.3 Argon

In this method, argon (0.93% by volume in ambient air) is not chromatographically separated from oxygen; therefore, results are reported as oxygen/argon.

5.0 SAFETY

Each compound, mixture of compounds, standards, as well as samples, should be treated as a potential health hazard. Exposure to these chemicals should be reduced to the lowest level possible through the use of hoods (to minimize inhalation). For proper handling, use and disposal refer to the laboratory's Environmental, Health and Safety Manual, MSDS (located in the conference room), as well as the ***SOP for Waste Disposal***.

5.1 Material Safety Data Sheets (MSDS)

Material safety data sheets (MSDS) are available in the conference room and shall be reviewed as part of employee training.

5.2 Safety Glasses

Safety glasses are required when performing maintenance on pressurized systems.

5.3 Pressurized Gases

The use of pressurized gases is required for this procedure. Care should be taken when moving cylinders. All gas cylinders must be secured to a wall or an immovable counter with a chain or a cylinder clamp at all times. The regulator should not remain on size "D" cylinders when not in use. Sources of flammable gases (i.e. pressurized hydrogen) should be clearly labeled.

6.0 SAMPLE COLLECTION, CONTAINERS, PRESERVATION, AND STORAGE

The samples are collected and delivered to the laboratory for analysis in either Tedlar bags or specially prepared canisters. Samples collected in bags must be analyzed within 72 hours after sample collection unless otherwise specified by the client. Samples delivered in cleaned, evacuated summa or other specially prepared canisters do not have a specified holding time for atmospheric gases but this laboratory recommends that samples be analyzed within 30 days from the date of collection.

7.0 APPARATUS AND EQUIPMENT

7.1 Gas Chromatograph

The analysis is performed using a Hewlett-Packard model 5890 series II gas chromatograph or equivalent equipped with a thermal conductivity detector.

7.1.1 Column 6' x 1/8" stainless steel column packed with 60/80-mesh carbosphere.

Conditioning of the chromatographic column is required prior to use of the system. The column should be conditioned with a continuous flow of chromatographic grade Helium and temperature programmed from 35°C to 200°C at a rate of five degrees per minute. The column should be held at 200°C for at least four hours.

7.1.2 Sample Loop Stainless steel tubing with a 1/16" diameter (various lengths).

7.1.3 Conditioning System The system is able to maintain the column and sample loop at a constant temperature.

7.2 Adsorption Tubes

In addition to a thermal gas purifier incorporated into the system, an oxygen trap shall be utilized to remove any O_2 from the carrier gas to help in extending the life of the TCD filaments.

7.3 Summa Canisters

Summa canisters may be supplied to the client for sampling purposes. These samples are submitted to the laboratory for analysis; therefore, the canisters must be conditioned and certified in accordance with the ***SOP for Cleaning and Certification of Summa Canisters and Other Specially Prepared Canisters***.

8.0 STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

All samples, standards, and media must be stored separately. The concentration, preparation and expiration date as well as analyst's initials must be identified on the standard label. Each standard must also be uniquely identified with a laboratory ID number.

All standard certificates shall be noted with the standard identification number, date received and initials of the receiving analyst. They must then be given to the quality assurance department where they will be maintained. For additional information on these and other requirements, refer to the ***SOP for Handling Consumable Materials***.

8.1 Carrier and Calibration Standard Balance Gas

8.1.1 Helium - UHP/ZERO (99.999%) or higher in purity

8.2 Standards

DoD compliance requires that second source standards be obtained from a second manufacturer. The use of a standard from a second lot is acceptable only when one manufacturer of the standard exists.

8.2.1 Purchased Standards

These standards must be stored in accordance with the requirements described in the ***SOP for Handling Consumable Materials***. These standards must be stored at ambient temperatures for a period of up to 2 years or as recommended by the manufacturer.

8.2.1.1 Scott Specialty Gas or Equivalent

Compound	Concentration
Carbon dioxide	~5.00%
Carbon monoxide	~5.00%
Hydrogen	~4.00%
Methane	~4.00%
Nitrogen	~5.00%
Oxygen	~5.00%
Balance Gas: Helium	

Note: The concentrations of these standards will change with each purchase and the specific concentration of each compound will be denoted on the standard as well as the Certificate of Analysis and used in all calculations.

8.2.1.2 Matheson or Equivalent

Compound	Concentration
Carbon dioxide	~5.00%
Carbon monoxide	~5.00%
Hydrogen	~4.00%
Methane	~4.00%
Nitrogen	~5.00%
Oxygen	~5.00%
Balance Gas: Helium	

Note: The concentrations of these standards will change with each purchase and the specific concentration of each compound will be denoted

on the standard as well as the Certificate of Analysis and used in all calculations.

8.2.1.3 AirGas or equivalent (Neat gas standards)

Compound	Concentration
Hydrogen	99.999%
Oxygen	99.999%
Nitrogen	99.999%
Methane	99.999%
Carbon Dioxide	99.999%

8.2.2 Ambient Air

Ambient air is analyzed once per batch to assess injector performance.

9.0 PREVENTIVE MAINTENANCE

A maintenance log shall be kept documenting maintenance performed on each analytical system and the instrument maintenance log must be kept current and reviewed quarterly. The serial numbers of each instrument shall be recorded in the front of the logbook. An entry must be made in the appropriate log each time any maintenance activity is performed (no matter the extent). The entry in the log must include:

(a) The date of maintenance
(b) Who did the maintenance
(c) Description of the maintenance
(d) Proof that the maintenance activity was successful.

A notation of a successful continuing calibration or initial calibration shall serve as proof that the maintenance is complete and the instrument is in working order.

9.1 Carrier Gas Purifier

If in-line purifiers or scrubbers are in place, these purifiers must be changed as recommended by the supplier.

9.2 GC System

9.2.1 Column Column performance should be monitored by observing peak shapes and column bleed. Over time, the column may exhibit a poor overall performance, as contaminated sample matrices are analyzed. The length of time for this to occur depends on the samples analyzed. When a noticeable decrease in column performance is evident and other maintenance options do not result in improvement, the column should be changed or the packing replaced (see **Section 7.1.1**). Care should be taken to minimize the introduction of air or oxygen into the column whenever GC maintenance is performed.

Decreasing performance can also be due to a leak in the system. Leaks can be detected with the use of a leak detector. Fittings may need to be tightened or ineffective column ferrules replaced to eliminate any leak detected.

9.2.2 Detector Replace filament assembly as needed.

9.2.3 Injection Lines Purge with nitrogen to ensure the line is not blocked.

10.0 RESPONSIBILITIES

It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review and reporting per the corresponding standard operating procedures. Laboratory personnel that have successfully demonstrated the ability to generate acceptable results according to this SOP are approved to perform sample analysis and interpretation of the results. This demonstration shall be in accordance with the training program of the laboratory described in **Section 19.0** and the ***SOP for Documentation of Training***. The department supervisor/manager or designee shall perform final review and sign-off of the data.

11.0 PROCEDURE

Sufficient raw data records must be retained of the analysis, instrument calibrations and method detection limit studies including: analysis/calibration date and time, test method, instrument, sample identification, each analyte name, analyst's initials, concentration and response, and standards used for the analysis and calibrations, manual integrations and all manual calculations including sample dilutions. Make sure that all information entered and reported on the quantitation report and instrument run log is complete and accurate. If manual integration is necessary the guidelines described in the ***SOP for Manual Integration of Chromatographic Peaks*** shall be followed.

11.1 Sample Preparation and Analysis Observations / Case Narrative Summary Form

This form, which is included in the ***SOP for Laboratory Storage, Analysis, and Tracking*** must be generated when there are any specific sample composition information, sample preparation, analysis issues and/or observations. In addition, during the analysis, specific identification information or problems, interferences, calibration issues, flags, and additional/expanded explanation of flags should be added to the form. This form may be modified as long as the sections and basic concepts are reserved.

This form is necessary as a means for documenting any unusual or noncompliant information. This form, among other information, will be reviewed when compiling the final report and case narrative. All information regarding the job shall remain in the file, in order that sufficient documentation is available to recreate the job from sample receipt through preparation, analysis, data reduction, and reporting.

11.2 Analytical Sequence and Data System Setup

11.2.1 Data System Load the appropriate analytical sequence (e.g., J:\GC1\sequence\fxgs_25c.s). Enter the analytical sequence information in the table window, including sample/standard name. Load the appropriate quantitation

analytical method (e.g., J:\gc1\methods\"appropriate ICAL"). Run the sequence and analyze the standards and samples in the order specified.

11.2.2 Analytical Sequence The analytical batch must be completed for the analysis of ≤20 field samples.

Analytical Sequence Guideline[1]

Sample Description(w/ICAL)	***Sample Description***
Calibration Stds.[2]	CCV[3]
ICV[4]	MB[5]
MB[5]	Lab Air[6]
Lab Air[6]	Samples 1-10[7]
Samples 1-10[7]	CCV[3]
CCV[3]	Samples 11-19[7]
Samples 11-19[7]	LD[8]
LD[8]	LCS[9]
CCV[3]	CCV[3]

[1] The batch QC may be analyzed in an order other than the one listed in this document; the analytical sequence specified below is a guideline.
[2]The initial calibration must be generated in accordance with the guidelines detailed in **Section 11.5.1** of this document.
[3]In cases, where the ICAL is not performed the analytical sequence must begin with the analysis of a CCV standard. In an external standard calibration the CCV is to be analyzed no less frequently than every ten samples or every 12 hours, which ever is more frequent, and the analytical sequence is to end with the analysis of a CCV standard.
[4]Every ICAL must be followed by a second source standard (ICV) which contains all of the target analytes. Same source as LCS; therefore, LCS is not required to be analyzed again.
[5]The method blank must be carried throughout the entire analytical process and be analyzed prior to any samples within the sequence. A method blank (MB) shall be run to monitor for laboratory introduced contamination.
[6]A volume of laboratory ambient air shall be analyzed at a rate of one per twenty sample injections or fewer.
[7]EPA Method 3C requires a duplicate injection for each sample. If the samples are being analyzed per a modified Method 3C, they are to be injected once (refer to note number 8). ASTM D 1946 requires only a single injection.
[8]Every batch must include the analysis of a laboratory duplicate. Samples selected for duplicate analysis shall be rotated among client samples. In addition, if performing EPA Method 3C without modification (duplicate injection), the laboratory duplicate analysis will not be necessary. A laboratory duplicate is considered a sample.
[9] A second source standard similar to 8.2.1.1 shall be analyzed once per twenty sample injections or fewer.

11.3 Conditions

The column and detector temperatures should be adjusted to the recommended levels. The column should be conditioned as instructed in **Section 7.1.1**. Once the GC/TCD system is optimized for analytical separation and sensitivity, the identical sample operating conditions must be used to analyze all samples, blanks, calibration standards and quality control samples.

The recommended settings and system parameters are as follows:

Sample Inlet: GC
Injection Source: Sample Loop
Run Time: ~8 min.

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Initial Temperature:	50°C	*Maximum Temperature*:	250°C
Initial Time:	2.0 min.	*Equilibration Time*:	0.0 min.

Ramps:	Rate:	30°/min.
	Final Temp.:	200°C
	Final Time:	1 min.

COLUMN		DETECTOR	
Type:	Packed	*Temperature:*	260°C
Model:	Carbosphere 60/80	*Reference Flow*:	45mL/min.
Dimensions:	6' x 1/8"	*He Make up*:	20mL/min.

11.4 Retention Time (RT) Windows

Retention time windows for each target analyte must be generated whenever there is a major change in instrument conditions including flow rates. Also, when standard analyses result in analyte retention times outside the established windows. The procedure for determining the retention time windows for this method is as follows. However, other approaches may be employed, providing that the analyst can demonstrate that they provide performance appropriate for the intended application. For example, the analyst may use the corresponding retention times from the initial calibration as they may show shifts in RTs due to the volume injected (higher concentrations lead to wider peaks).

1. Make sure that the system is operating reliably and that the system conditions have been optimized for the target analytes in the sample matrix to be analyzed.
2. Make four injections of all applicable standard mixes over a 72 hour period. Make the injections cover the entire 72-hour period or the end result could be windows, which are too tight.
3. Record the retention time for each single component analyte to three decimal places. Calculate the mean and standard deviation of the four absolute retention times for each single component analyte and surrogate
4. If the standard deviation of the retention times for the target compound is 0.000, then additional injections may be included or the use of a default standard deviation of 0.01 minutes.
5. The width of the retention time window for each analyte is defined as ±3 times the standard deviation of the mean absolute retention time established during the 72 hour period. If the default standard deviation of 0.01 is used, the width of the window will be 0.03 minutes.
6. Establish the center of the retention time window for each analyte by using the absolute retention time for each analyte from the continuing calibration verification standard at the beginning of the analytical shift. For samples run during the same shift as an initial calibration, use the retention time of the mid-point standard of the initial calibration.

7. Retention time windows must be calculated for each analyte on each instrument. New retention time windows must be established when a new column is installed.

11.5 Initial Calibration

Record the detector temperatures, GC temperature program, standard concentrations, and sample loop volume. All of the following information must be retained to permit reconstruction of the initial instrument calibration: calibration date, test method, instrument, analysis date, each analyte name, analyst's initials; concentration and response, response factor. Refer to **Section 12.1** for the acceptance criteria .

11.5.1 Analysis Guidelines

- Analyze differing concentrations covering the desired calibration range by utilizing different sample loops. The dynamic range may be amended as long as all documentation reflects the correct concentrations.
- An ICAL shall be performed at a minimum annually.

11.5.2 Initial Calibration Requirements

Once a set of ICAL standards is analyzed, the previous ICAL may no longer be used to analyze new samples and it must be archived. The only time an archived ICAL can be used thereafter is to review or re-evaluate samples(s) previously processed using that ICAL.

1. A minimum of 5 concentrations, must be used to calculate the calibration curve
2. Highest concentration, together with the lowest concentration, defines the calibration curve.
3. Lowest concentration must be at or below the method reporting limit.
4. The initial calibration event may not be interrupted by maintenance.
5. Only one value per concentration may be used.
6. Analyze calibration standards from low to high concentration.
7. All ICAL analyses must be completed within 48 hours.
8. One injection per 5 points (2 per 6) may be re-analyzed to replace "bad" injection(s).
9. Point dropping policy:
    - The following are guidelines to follow if points are to be reviewed to determine the appropriateness of dropping a point or injection.
    - Lowest concentration must be at the MRL and may not be dropped unless another concentration is added to the upper end of the curve. This would in turn raise the MRL.
    - Points at the high end may be dropped but another concentration must be added and used in the calculation. The curve range must be noted.
    - Points must not be dropped from the "interior" of a curve unless there is an assignable cause* for doing so that affects many (if not all) the analytes in the calibration standard. If a calibration standard is to be dropped from the interior of the curve, all the analytes in the calibration standard must be dropped from all the analytes' calibration curves.

- If a point or a calibration standard is dropped, the reason must be documented (and the results maintained with the documentation for the final ICAL).
- A calibration standard may be re-analyzed if the first analysis of the standard has been dropped and other requirements in this policy are met (i.e., still within 48 hours).
- Once the ICAL has been used to calculate and report sample results, it is not to be changed.

* Assignable causes include -

- Standard preparation error;
- Instrument malfunction (e.g., it quits acquiring in the middle of the analysis);
- Bad injection or purge

10. A set of concentrations for a calibration curve is in the following table (Attachment F). However these concentrations might change due to the availability of the standards. Other concentrations can be used as long as all other guidelines for the analysis of initial calibration are followed.

Note: Hydrogen may not be linear; therefore, if an average response factor or linear regression cannot be used, a quadratic curve fit may be employed. A quadratic (second order) model requires a minimum of five calibration points.

11.5.3 Initial Calibration Review

The ICAL checklist is used to document the review and approval process. The Analyst's calculation and assessment along with a peer review of all ICAL data and documentation as stated in Attachment B is required before the ICAL may be used to analyze samples.

11.5.4 Initial Calibration File

An ICAL file is to be created for each initial calibration performed per instrument into which is placed the following ICAL documents. The file shall remain in the laboratory and be filed by instrument and date.

- ICAL Checklist filled out, reviewed and approved
- Blank analysis quantitation report
- Calibration status report (aka Calibration History)
- Relative Response Factor Report / Percent Relative Standard Deviation
- Plot for quadratic fit for hydrogen, if necessary
- Quantitation report for each calibration standard (including manual integration documentation – before and after manual integration)
- ICV quantitation report and evaluate continuing calibration report (aka Percent Difference Report)
- Injection log (optional)

11.5.5 Initial Calibration Verification Verify the initial calibration by analyzing an independent calibration verification standard (ICV). Utilize the standard

described in **Section 8.2.1** for the analysis of a second source standard. Refer to **Section 12.2** for acceptance criteria.

11.5.6 LOQ Establishment, Verification & Acceptance Criteria

A) The LOQ must be set within the calibration range (≥ low std. of the current passing ICAL) prior to sample analysis.
B) The LOQ for each analyte must be ≥ the analyte's LOD.
C) Initially a passing demonstration of precision and bias must be performed at the LOQ
D) Run CCV 2 times at LOQ and:
   1) Evaluate the LOQ for precision and bias using current control chart limits.
   2) Check the signal to noise ratio (S/N) using the software. The S/N ratio must be at least 3:1 for each analyte.
E) If anything fails, verify at higher level and notify reporting. Also, make a note in the ICAL documentation.
F) Turn in all LOQ verification data (quant reports and software reports/checks) to QA (regardless of pass/fail).
G) Verify the LOQ on each instrument quarterly by running the CCV at the LOQ and verifying that ongoing precision and bias requirements are met.

11.6 Continuing Calibration Verification

A continuing calibration check shall be performed at the beginning and end of an analytical sequence and every ten field samples, not to exceed a 12 hour period. The concentration of the calibration verification may be varied within the established calibration range. Refer to **Section 12.3** for acceptance criteria.

11.7 Laboratory Control Sample - LCS

A second source standard similar to **Section 8.2.1.1** shall be analyzed once per closed batch. Refer to **Section 12.8** for acceptance criteria.

11.8 Method Blank

A method blank must be analyzed by sampling chromatographic grade helium. Refer to **Section 12.5** for acceptance criteria.

11.9 Sample Analysis

Refer to **Section 12.7** for the acceptance criteria.

11.9.1 Canister Pressurization Sample analysis must be made using the same instrument parameters as that of the calibration standards. Refer to the ***SOP for Evaluation and Pressurization of Specially Prepared Stainless Steel Canisters*** for the procedure of how canisters are to be pressurized prior to analysis. The analyst shall record the appropriate pressures on the Service Request form.

11.9.2 Sample Analysis Sample analysis is performed with the utilization of a sample loop equipped with a pump. If the sample container is not equipped with a sampling valve appropriate for this use, the sample container shall be fitted with an adapter. The dead volume within the adapter shall be evacuated and the sample loop flushed then filled with sample gas. Analyze each sample in duplicate (calculate the percent difference of the calculated concentration of each analysis) unless performing a single injection modification or referencing ASTM D 1946 (refer to **Section 11.9.3, #2**).

11.9.3 Sample Re-analysis

1. If the response of any permanent gas analyte in a sample is greater than the response of that analyte in the ICAL (outside the ICAL upper calibration range) the sample shall be reanalyzed using a smaller loop.

   Dilution (i.e. Tedlar bags) would compromise sample integrity with the addition of laboratory air. Guidance in performing dilutions and exceptions to this requirement are given below.

   - The dilution factor chosen should keep the response of the analyte peak for a reported target compound in the upper half of the initial calibration range of the instrument. Additional compounds may be reported as long as they are within the calibration range.

2. If the percent difference between the duplicate injection (analysis without modification) is greater than the acceptance criterion of 5%, the sample must be re-analyzed and repeated until acceptable *consecutive* numbers are achieved.

11.10 Laboratory Duplicate (LD)

If the method is being performed with a single injection modification, then the analysis of a LD is required to show precision. The laboratory duplicate should be rotated among clients, whenever possible. Refer to **Section 12.6** for acceptance criteria.

11.11 Manual Integration

The integration for each peak is checked to ensure that it has been integrated properly. Assuming an incorrect automatic integration the analyst shall conduct the manual integration in accordance with the ***SOP for Manual Integration of Chromatographic Peaks*** including all documentation and reviews associated with the process. The review shall include the analyst and peer reviewer initialing and dating the manual integration as an indication of acceptability and approval.

11.12 Detection Limits and Limits of Detection

If results are to be reported below the MRL, an MDL study must be performed in accordance with the procedure outlined in the ***SOP for Performing Method Detection Limit Studies and Establishing Limits of Detection and Quantitation***. Method detection limits must be determined annually and each time there is a change in the test method that affects how the test is performed, or when a change in instrumentation is such that it

affects the sensitivity of the analysis. The MDL study shall be performed on each instrument for which this method is performed. All supporting data must be approved and retained.

The detection limit shall be used to determine the LOD for each analyte. Once determined on each instrument, the highest LOD (for each analyte from all instrument determinations) shall be used as the uniform LOD.

11.12.1 Performance and Acceptance Criteria

1. Perform Limit of Detection (LOD) verification on all instruments (performing this method) immediately following the MDL study. Spike the LOD at 1-4x the MDL; the spike level establishes the LOD.
2. LOD Acceptance
   - Analyte must be detected reliably and identified by the method-specific criteria and produce a signal that is at least 3 times the instrument's noise level (3:1 signal to noise ratio).
   - It is specific to each combination of analyte, matrix, method and instrument configuration.
   - The LOD must be verified quarterly on each instrument (spiked at LOD) using the criteria listed above.
3. If the LOD verification fails (per #2), repeat the detection limit determination and LOD verification at a higher concentration or perform and pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration.
4. The laboratory shall maintain documentation for all detection limit determinations and LOD verifications (regardless of pass or fail).

Note: Per the DoD QSM 4.2 and TNI/NELAC Standard, it is not necessary to perform a MDL study when results are not to be reported below the LOQ/MRL.

11.13 Storing Electronic Data

The initial calibration data must be stored in a quantitation method (on the server) using a unique filename and may not be overwritten at any time in order to maintain an accurate audit trail. Files shall be named with a two-character notation indicating the compound list and the date of the corresponding initial calibration. In addition, all data files including method blanks, continuing calibration verification, laboratory control samples and client submitted samples files shall be saved in a unique sub-directory on the server. An example of how the analyst must store analytical data is as follows:

Instrument Number/Data/Method ID/yr_month/*.d

* Injection (automatically assigned based on order of injection)

11.14 Ambient Air

An ambient laboratory air sample shall be analyzed once per closed batch (20 or fewer sample injections). Refer to **Section 12.4** for the acceptance criteria and corrective action.

12.0 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

This section of the standard operating procedure contains technical acceptance criteria. To the extent possible, samples shall be reported only if all of the quality control measures are acceptable. If a quality control measure is found to be out of control, and the data must be reported, all samples associated with the out of control quality control measure shall be reported with the appropriate data qualifier(s).

12.1 Initial Calibration

If a quadratic fit (for hydrogen) is used it should be forced through zero.

12.1.1 Acceptance Criteria

- The percent relative standard deviation (%RSD) for the response factors must be ≤15% for all compounds except hydrogen if utilizing a quadratic curve.
- Hydrogen may be fitted to a quadratic curve where the coefficient of determination (COD) shall be ≥0.99.
- The retention time for each point must within 0.06 minutes of the mean RT. The higher levels of hydrogen (due to the large volume) may not meet, which is acceptable.

12.2 Initial Calibration Verification Standard (ICV)

12.2.1 Acceptance Criteria

- The percent difference for each compound in the ICV must be ≤15%.

12.3 Continuing Calibration Verification (CCV)

12.3.1 Acceptance Criteria

- The percent difference for each analyte in the CCV must be ≤10%, except hydrogen which must be ≤15%.
- The retention time for each analyte in the standard must be within 0.33minutes of the mean RT (of the corresponding analyte) from the ICAL.

12.4 Ambient Air

12.4.1 Acceptance Criteria

- The sum of the results for nitrogen and oxygen/argon must fall between 90% and 110% (un-normalized).

12.5 Method Blank

12.5.1 Acceptance Criteria The method blank result for any target analyte must not be greater than the method reporting limit. Also, the blank should not contain

additional compounds with elution characteristics that would interfere with identification and measurement of a target analyte.

For DoD samples, the method blank will be considered to be contaminated if:

1.) The concentration of any target analyte in the blank exceeds 1/2 the reporting limit and is greater than 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater);
2.) The concentration of any common laboratory contaminant in the blank exceeds the reporting limit and is greater than 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater); or
3.) The blank result otherwise affects the samples results as per the test method requirements or the project-specific objectives.

The laboratory shall evaluate whether reprocessing of the samples is necessary based on the above criteria.

12.6 Laboratory Duplicates (Modified EPA Method 3C)

12.6.1 Acceptance Criteria

Every batch of twenty or fewer samples, if performing EPA Method 3C with modification, must include the analysis of a laboratory duplicate as a measurement of method precision. Refer to Attachment D of this document.

12.7 Sample Analysis

Samples out of holding time must be handled according to **Section 16.9**.

12.7.1 Acceptance Criteria

- The sample replicate injections are acceptable when the RPD is within ±5% (analysis without modification must consist of consecutive injections).
- Analyte retention time must be within the daily RT window and within 0.33minutes of the mean RT in the ICAL.

12.8 Laboratory Control Sample (LCS)

12.8.1 Acceptance Criteria The percent recovery must fall within the fixed recoveries of 85-115% or laboratory generated control limits when available. Refer to Attachment D.

13.0 DATA REDUCTION AND REPORTING

The essential information to be associated with analysis, such as computer data files, run logs, etc. shall include: Sample ID code, date and time of analysis (both are required for Tedlar bags since the holding time is 72 hours), instrument operating conditions/parameters (or reference to such data), analysis type, manual integrations, all manual calculations, analyst's initials, sample preparation (pressure readings and balance gas), standard and reagent origin, sample receipt,

calibration criteria, frequency and acceptance criteria, data and statistical calculations, review, confirmation, interpretation, and assessment and reporting conventions.

13.1 Initial Calibration

- Response Factor for each injection (equation number 5)
- Mean Response Factor using all injections (equation number 6)
- Percent Relative Standard Deviation (equation numbers 5,6,7, and 8)

Hydrogen:

- Coefficient of Determination (equation number 12)

13.2 Initial Calibration Verification

- Response Factor (equation number 5)
- Mean Area Response (equation number 6)
- Percent Difference (equation number 3)

13.3 Continuing Calibration Verification

- Response Factor (equation number 5)
- Mean Area Response, where necessary (equation number 6)
- Percent Difference (equation number 3)

13.4 Laboratory Duplicate and Method 3C without modification

- Relative Percent Difference (equation number 4)

13.5 Sample Analysis

Sample results must be quantitated from the initial instrument calibration and may not be quantitated from any continuing instrument calibration verification.

All permanent gas results are normalized as dry gas to 99.99% proportionately, in order to reflect the true composition of the sample. It is the practice of the laboratory to normalize results of permanent gas analysis, except under special circumstances that occur where the normalization of the results is not utilized or the normalization procedure is modified. For example, samples containing greater than 0.01% by volume of measured constituents other than permanent gases (for instance high hydrocarbon or sulfur levels) are normalized to 99.99% minus the percent contribution from components other than permanent gases.

- Calculate the average area of the two injections, where necessary (equation number 2)
- Calculate the dilution factor, where necessary (equation number 1)
- Analyte concentration (equation number 9)
- Hydrogen concentration (equation number 14)
- Normalization (equation number 11)

When the analysis of a sample produces permanent gas results whereby the total is significantly less than expected, accounting for experimental, error it is the laboratory's practice to reanalyze the sample in question as well as the laboratory air. This will determine if there is a problem with the analytical system. If there is no problem with the system and the results are the same refer to the following example.

If the total of the permanent gas analysis is less than 60.0% by volume and the laboratory is not requested to perform additional analyses, the results would be reported unnormalized. The decisions whether to report the unnormalized results is at the discretion of the analyst and department supervisor.

13.6 Laboratory Control Sample

- Calculate the percent recovery (equation number 10)

13.7 Calculations

13.7.1 Equation Number 1

Dilution Factor

$$DF = \frac{V_{STD}}{V_S}$$

Where:

DF = dilution factor
V_{STD} = volume of standard loop
V_S = volume of sample loop

13.7.2 Equation Number 2

Average

$$\frac{x + y}{n}$$

where:

x = response from the first injection
y = response from the second consecutive injection
n = number being averaged together.

13.7.3 Equation Number 3

Percent Difference, %D,

The %D is used for evaluating ICV and CCV vs. the initial calibration

$$\%D = \frac{C_{CCVorICV} - C_{std}}{C_{std}}(100)$$

where, for any given analyte:

$C_{CCVorICV}$	is the calculated concentration being evaluated.
C_{std}	is the concentration of the standard used.

13.7.4 Equation Number 4

Relative Percent Difference (RPD)

$$\frac{|R_1 - R_2|}{\left(\frac{R_1 + R_2}{2}\right)} x100$$

where:

R_1	First measurement value
R_2	Second measurement value

13.7.5 Equation Number 5

Response Factor (RF)

The response factor, for analyte *x* is given by:

$$RF = \frac{A_x}{C_x}$$

where:

A_x = Area of the analyte in the standard
C_x = Concentration of the analyte in the standard

13.7.6 Equation Number 6

Average (or Mean) RF

$$\overline{RF} = \frac{\sum_{i=1}^{N} RF_i}{N}$$

where:

RF_i are the individual RFs from each injection in the initial calibration curve.
N is the number of injections.

13.7.7 Equation Number 7

Standard Deviation, SD:

$$SD = \sqrt{\sum_{i=1}^{N} \frac{\left(RF_i - \overline{RF}\right)^2}{N-1}}$$

where:

RF_i are the individual RFs from each concentration level in the initial calibration curve.
$\overline{RF}$ Average (or Mean) RF of all injections in the initial calibration curve.
N total number of injections.

13.7.8 Equation Number 8

Percent Relative Standard Deviation, %RSD:

$$\%RSD = \frac{SD}{\overline{RF}}(100)$$

where:

SD Standard Deviation calculated in equation number 3
$\overline{RF}$ Average or Mean RF

13.7.9 Equation Number 9

Concentration (C):

$$C = \frac{Area}{\overline{RF}} \times \frac{D_{SLV}}{A_{SLV}}$$

or

$$C = \frac{\overline{Area}}{\overline{RF}} \times \frac{D_{SLV}}{A_{SLV}}$$

where:

Area	is the area obtained from the chromatogram.
$\overline{Area}$	Mean area for both injections, if performing analysis without modification
$\overline{RF}$	Average (or Mean) RF of all concentration levels in the initial calibration curve.
D_{SLV}	default sample loop volume
A_{SLV}	actual sample loop volume

13.7.10 Equation Number 10

Percent Recovery (%R):

$$\%R = \frac{C}{S} x100$$

where:

C = Concentration of the analyte recovered
S = Spiked amount

13.7.11 Equation Number 11

Normalization

Divide each analyte's calculated concentration (percent) by the percent sum of the permanent gases in the sample and multiply by 99.99 or the adjusted value.

13.7.12 Equation Number 12

Quadratic (Coefficient of Determination)

$$COD = \frac{\sum_{i=1}^{n}(y_{obs} - \bar{y})^2 - \left(\frac{n-1}{n-p}\right)\sum_{i=1}^{n}(y_{obs} - Y_i)^2}{\sum_{i=1}^{n}\left(y_{obs} - \bar{y}\right)^2}$$

where:

y_{obs} = Observed response (area) for each concentration from each initial calibration standard
$\bar{y}$ = Mean observed response from the initial calibration
Y_i = Calculated response at each concentration from the initial calibration

n = Total number of injections
p = Number of adjustable parameters in the polynomial equation (i.e., 3 for a third order; 2 for a second order polynomial)

13.7.13 Equation Number 13

Quadratic Fit

$R = AX^2 + BX + C$

where:

R = response
X = quantity, ng
A, B and C = are coefficients in the equation

13.7.14 Equation Number 14

Analyte Concentration (using equation number 13)

$$X = \frac{\sqrt{4A(R-C)+B^2} - B}{2A}$$

13.8 Data Review

The analyst must review data on a real time basis for all calibration and QC data. The QC data must be evaluated following the data review checklist in Attachment C. The data shall be reviewed and the sample results calculated and assessed by one analyst and reviewed by a second qualified analyst. The data review checklist shall be used to document the review process. Once it has been completed, the checklist must be initialed, dated and filed with each job file. Results must not be reported until after they are appropriately reviewed according to this SOP, the ***SOP for Data Review and Reporting*** and the ***SOP for Ensuring Data Integrity***.

Initial calibrations must be reviewed in the same manner as QC data with all ICAL documentation retained in a separate file. Refer to the initial calibration checklist in Attachment B for the review guideline. The ICAL file must contain all the pertinent information stated in **Section 11.5.4**.

13.9 Reporting

The results of each test shall be reported clearly, unambiguously and objectively, and shall include all the information necessary for the interpretation of the test results and all information required by this SOP and the ***SOP for Data Review and Reporting***. The following are situations whereby the results shall be reported as being analyzed by Modified EPA Method 3C: single injection, reporting hydrogen and carbon monoxide

and if analyzing replicate injections (for 3C without modification) and the samples are submitted in Tedlar bags.

13.9.1 EPA Method 3C Modifications

- Single injection
- Sample container other than backfilled Summa canisters
- Reporting carbon monoxide and /or hydrogen

14.0 METHOD PERFORMANCE

An on-going assessment of method performance is conducted in order to ensure that the laboratory is capable of reporting results which are acceptable for its intended use. Validation of the method is confirmed by the examination and provision of objective evidence that these requirements are met.

14.1 Method Detection Limit (MDL)

The procedure used to determine the method detection limits are as stated in the *Code of Federal Regulations* (40 CFR 136 Appendix B) as defined in the ***SOP for Performing Method Detection Limit Studies and Establishing Limits of Detection and Quantitation***. The MDL is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. MDLs can be obtained using standards at a concentration of about 300ppm to 1000ppm and making at least seven replicate measurements of the compounds of interest, computing the standard deviation, and multiplying this value by the appropriate Student's t value for 99 percent confidence.

The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects. Refer to **Section 11.12.1** for the LOD verification criteria.

Note: Per the DoD QSM 4.2 as well as the TNI / NELAC Standard, it is not necessary to perform a MDL study when results are not to be reported below the LOQ/MRL.

14.2 Accuracy and Precision

Refer to **Section 12.6** for information on replicate precision criteria for method performance. Single laboratory accuracy is presented as the second source initial calibration verification standard, which meets the method performance criteria of 15%. Additionally, laboratory generated control limit data for LCSs are presented for the analytes of interest and may be referenced in attachment D. Refer to **Section 11.5.6** for the accuracy and precision LOQ requirements.

14.3 Demonstration of Capability

This laboratory has continuously performed this method since before July 1999. Ongoing demonstration of capability shall be performed and documented; however, the initial demonstration of method capability is not required.

15.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

All waste management must be carried out in accordance with the requirements detailed in the ***SOP for Waste Disposal*** as well as the Environmental Health and Safety Manual.

16.0 CORRECTIVE ACTIONS FOR OUT-OF-CONTROL DATA

It must be determined if there are any instrumentation problems contributing to out of control QC data and the analyst must determine if this has affected sample results. This being the case, all samples (including QC) that are affected by instrumentation problems must be re-analyzed following any necessary maintenance activity. Corrective actions shall follow the procedures outlined in the ***SOP for Corrective Action***, where appropriate.

16.1 ICAL Does Not Meet Criteria

If the initial calibration technical acceptance criteria are not met, inspect the system for possible sources. Check standards and re-analyze (per ICAL policy in **Section 11.5.2**), if necessary. Also, it may be necessary to perform maintenance or perform other corrective actions to meet the technical acceptance criteria. Attempt another initial calibration and make a notation in the maintenance logbook regarding any maintenance steps taken. If the recalibration does not meet the established criteria, new calibration standards must be made. A demonstration of an in-control system is required before proceeding with the analysis.

16.2 ICV Does Not Meet Criteria

If the ICV does not pass the criteria the standard must be reanalyzed and reevaluated. If reanalysis also fails to produce an acceptable recovery, documented corrective action must be initiated. This may include instrument maintenance, a new ICV standard or the analysis of a new initial calibration curve.

16.3 CCV Does Not Meet Criteria

If the continuing calibration fails to meet expected criterion, the CCV may be reanalyzed (no more than two runs of the CCV standard may be analyzed without documented corrective action, i.e. a notation in the logbook). If the acceptance criterion is still not met, it may be necessary to perform maintenance prior to reanalysis. If routine maintenance does not correct the problem, a new initial calibration must be performed on the instrument.

If the retention time criterion is not met, leak check the system, check the carrier gas cylinders, determine if there has been a loss of pressure in lines. If the analytes do not fall within the generated windows, a new retention time window should be generated.

16.4 Unacceptable Ambient Laboratory Air Data Results

Reanalyze the lab ambient air and if the results still do not meet the criterion, the sample line should be purged with nitrogen to release any blockage. This is particularly important if the results for the first criterion are low. Also, if the result is low the system should be checked for leaks. All standards, samples and QC samples associated with the lab ambient air should be reanalyzed following the maintenance activity if it is determined that the results could have been affected.

16.5 Method Blank (MB) Contamination

Re-inject the method blank and if the results are the same, analyze an instrument blank (inject without turning on the pump) to determine if the contamination is the blank canister or the analytical system. Corrective action documentation must be initiated following a failed second analysis. If the system is contaminated, then both the method blank(s) and the associated samples in question must be re-analyzed.

16.6 Unacceptable Laboratory Control Sample (LCS) Result

If the LCS criteria are not met, determine whether the cause is instrumentation problems, result of poor injection or a poor LCS. If necessary perform maintenance, re-inject the LCS or make a new standard. If the LCS criteria are still not met, a new ICAL must be run or the data must be qualified.

16.7 Unacceptable Laboratory Duplicates (Modified EPA Method 3C)

If the replicate results do not fall within the technical acceptance window, the sample should be re-analyzed. If the results are still unacceptable and there does not appear to be any matrix effects, interfering peaks, or instrument problems, the results for both injections shall be reported to the client with the appropriate qualifier.

16.8 Unacceptable Sample Analysis Data

Analysis Without Modification - If the two injections do not agree, run additional samples until consistent area data are obtained.

Analysis With or Without Modification – If the retention time for any analyte falls outside of the retention time window from the latest daily calibration or average initial calibration retention time, the system must be inspected for a change in the head pressure and the results evaluated and reported accordingly.

Results not bracketed by initial instrument calibration standards (within calibration range) must be reported as having less certainty, e.g., defined qualifiers or flags.

16.9 Expired Sample Holding Time

The customer shall be notified by the Project Manager (best attempt) when informed by an Analyst, Team Lead or SMO that the sample's holding time was missed. The customer must decide if the sample analysis shall continue. The documentation of missed holding time and the client's decision to proceed must be included in the corresponding job file. A statement dictating all holding time occurrences must accompany the sample results in the final report.

17.0 CONTINGENCIES FOR HANDLING OUT-OF-CONTROL OR UNACCEPTABLE DATA

To the extent possible, samples shall be reported only if all of the quality control measures are acceptable. If a quality control measure is found to be out of control, and the data must be

reported, all samples associated with the out of control quality control measure shall be reported with the appropriate data qualifier(s) as detailed in Appendix D of the most current Quality Assurance Manual.

17.1 When analysis quality control results are unacceptable:

If the associated samples are within holding time, re-analyze the sample with criteria under control. Alternatively, evaluate the effect on the sample results and report the results with qualifiers and/or discuss in the case narrative if the effect is judged insignificant.

17.1.1 Method Blank If an analyte in the method blank is found to be unacceptable and the analyte is also found in associated samples, those sample results shall be "flagged" in the report. If the analyte is found in the blank but not in the sample and all other quality control meets acceptance criteria then the results for the sample may be reported without a qualifier. However, if other QC is out of control then an evaluation must be made and the results reported accordingly.

17.1.2 Laboratory Duplicate (Analysis with Modification) If the results from the reanalysis are unacceptable, and there does not appear to be any matrix effects, interfering peaks, or instrument problems, the results for both injections shall be reported to the client. In addition, other results from the same analytical sequence should be reported with the appropriate qualifier.

17.1.3 Laboratory Control Sample An unacceptable LCS must be evaluated along with the sample analysis and reported accordingly.

17.1.4 Initial Calibration Sample data may NOT be reported with an unacceptable ICAL.

17.1.5 CCV Sample data associated with an unacceptable calibration verification may be reported as qualified data under the following special condition:

When the acceptance criteria for the continuing calibration verification are exceeded high, i.e., high bias, and there are associated samples that are non-detects, then those non-detects may be reported. Otherwise the sample affected by the unacceptable CCV shall be reanalyzed after a new calibration curve has been established, evaluated and accepted.

17.2 Sample Out of Control

17.2.1 Hold Time All Tedlar bag samples analyzed outside of the required hold time of 72 hours must be reported with the appropriate qualifier.

17.2.2 Retention Time All analytes outside of the retention time window (following a retention time evaluation) must be reported with the appropriate qualitative uncertainty, where necessary.

17.2.3 Duplicate Results (Analysis without modification) If the results from any of the repeated injections are still unacceptable (and other sample results were

acceptable), and there does not appear to be any matrix effects, interfering peaks, or instrument problems, the results for both injections shall be reported to the client. If the out-of-control results are due to matrix interferences, report the results with a matrix interference qualifier.

18.0 REFERENCES

18.1 **"**Determination of Carbon Dioxide, Methane, Nitrogen, and Oxygen from Stationary Sources", EPA Method 3C

18.2 ASTM D 1946-90 (Reapproved 2006), "Standard Practice for Analysis of Reformed Gas by Gas Chromatography".

18.3 *Department of Defense Quality Systems Manual for Environmental Laboratories, Version 4.2, 10/25/2010.*

18.4 SOP for Batches and Sequences, SOP Code ADM-BATCH_SEQ

18.5 SOP for Making Entries into Logbooks and onto Analytical Records, SOP Code ADM-DATANTRY

18.6 SOP for Performing Method Detection Limit Studies and Establishing Limits of Detection and Quantitation, SOP Code ADM-MDL

18.7 SOP for Manual Integration of Chromatographic Peaks, SOP Code ADM-INT

18.8 SOP for Corrective Action, SOP Code ADM-CA

19.0 TRAINING PLAN

Training demonstrations shall be conducted in accordance with the ***SOP for Documentation of Training,*** DoD QSM 4.2 (Requirement Box 25) and TNI / NELAC requirements. An initial demonstration of proficiency must be performed prior to independent analyses of samples. In addition, a continuing demonstration must be performed annually.

19.1 Demonstration of Capability

19.1.1 Quarterly Demonstration A demonstration of method sensitivity must be performed *quarterly on each instrument* performing this method.

1) A spike at the current LOD must be analyzed.
2) Verification of precision and bias at the LOQ must be performed.

Refer to **Section 11.5.6** (LOQ) and **11.12.1** (LOD) for additional information on how these demonstrations are to be performed as well as the acceptance criteria.

19.1.2 Annual Demonstration Each analyst must perform this demonstration both initially and annually. Analyze four LCS standards at 1-4x the MRL (LOQ) either concurrently or over a period of days as a verification of precision and bias of the quantitation range. The standard deviation (n-1) and average percent

recovery of the four replicates are compared against current laboratory control limits for precision and bias. See attachment D.

19.1.3 Change in Personnel, Instruments, Method and/or Matrix The requirements in **Sections 19.1.1** and **19.1.2** must be performed per the schedule noted and when there is a change in personnel, instruments, method or matrix. "Change" refers to any change in personnel, instrument, test method, or sample matrix that potentially affects the precision and bias, sensitivity, or selectivity of the output (e.g., a change in the detector, column type, matrix, or other components of the sample analytical system, or a method revision).

All attempts at this demonstration must be completed and turned into the QA department for retention. Once performance is found to be acceptable, a required certification statement will be completed by the QA Program Manager and either the immediate supervisor or Laboratory Manager and retained on file as a demonstration of compliance.

20.0 METHOD MODIFICATIONS

20.1 A modification that may be performed to this SOP for EPA 3C is a single sample injection and the addition of hydrogen and carbon monoxide. Also sample results are normalized as per ASTM D 1946. Use of sample containers other than backfilled Summa canisters must also be reported as a modification to the method.

20.2 The modification for ASTM D 1946 is the omission of ethane and ethene.

21.0 INSTRUMENT SPECIFIC ADDENDUM

21.1 Loop Calibration. The loop injection port has a standard loop of approximately 100ul to introduce sample to the instrument. There are other loops that are used to introduce smaller and larger amounts and these are calibrated against the normal loop for a known dilution factor.

21.1.1 Calibration Procedure. A standard of approximately 50000ppm for all analytes is analyzed three times with the normal loop. The area counts for all analytes with the exception of hydrogen are summed for each standard. This summation is averaged of the three standard injections. This procedure is duplicated using another loop. The dilution factor is the ratio of the average area counts of the normal loop divided by the average area counts of the other sampling loop.

For current Loop Ratios see Table 1.

22.0 CHANGES TO PREVIOUS REVISION

SOP Title	Revised to include Modification
Whole Document	All DoD and NELAC references updated; Section references updated as needed due to revisions; unnecessary/excessive section references removed
Section 2.0	Last sentence of first paragraph reworded
Section 3.14	Expanded definition

Section 4.0	Column conditioning moved to 7.1.1 and subsequent sections renumbered
Section 5.0	Revised 1st paragraph
Section 6.0	Lab recommended hold time is 30 days
Section 7.1.1	Added column conditioning information previously in section 4.0
Section 8.0	Reworded 2nd paragraph
Section 8.2	Added 1st paragraph to clarify DoD requirement
Section 9.0	Revised wording
Section 9.2.1	Added "Decreasing" to 2nd paragraph
Section 10.0	Revised to reflect current procedure
Section 11.5.2	Revised Note
Section 11.5.6	B) corrected ">" to "≥"
Section 11.12	Updated SOP title
Section 12.0 and subsections	Corrective actions moved to section 16.0
Section 12.8.1	Revised to include lab generated control limits and reference to Attachment D
Section 13.8 and 13.9	Added references to SOP for Data Review
Section 13.9.1	Added "Modifications" to heading to add clarity
Section 13.9.2	Removed section with incorrect information
Section 14.1	Updated SOP title
Section 14.3	Revised
Section 15.0	Updated titles
Section 16.0 and subsections	Revised (added information previously in section 12.0)
Section 17.1.5	Expanded section
Section 18.0	Updated references
Section 19.0	Added information previously in section 19.1
Section 19.1	Removed first paragraph (Incorporated information into other areas of section); added information to last paragraph
Section 20.1	Added last sentence
Table 1	Previously attachment G
Attachment C	Added #10 and revised #6
Attachment D	Combined attachments for Control Limits and Reporting Limits; Removed note on first table and "*Fixed Limits" on second table

23.0 ATTACHMENTS

Table 1:	Loop Ratios
Attachment A:	Training Plan for Analysis of EPA 3C by GC
Attachment B:	3C by GC Initial Calibration Checklist
Attachment C:	3C by GC Analyses Data Review Checklist
Attachment D:	Target Compounds Reporting Limits and Laboratory Control Limits
Attachment E:	Calibration Curve Concentrations

Table 1:

Loop Ratios	
Small Loop Ratio	0.1868
Large Loop Ratio	11.6933

Note: New loop ratios may be established prior to the revision of this document, refer to the most recent loop ratios.

Attachment A

Training Plan for Analysis of Fixed Gases by EPA Method 3C / ASTM D 1946

Training Plan for Analysis of Fixed Gases by GC/TCD

SOP Title: Fixed Gases by GC/TCD Revision: _____ Date: _____

Trainee: _____ Trainer: _____ Instrument: ☐ GC 1 ☐ GC ____

1. Read SOP — Trainer: ____ Trainee: ____ Date: _____

2. Read Methods: EPA Method 3C & ASTM D 1946 — Trainer: ____ Trainee: ____ Date: _____

3. Demonstrated understanding of the scientific basis of the analysis — Trainer: ____ Trainee: ____ Date: _____
   Gas Chromatography, Thermal Conductivity Detectors

4. Demonstrated familiarity with related SOPs — Trainer: ____ Trainee: ____ Date: _____
   SOP for Batches and Sequences; Rev. ____
   SOP for Making Entries into Logbooks and onto Analytical Records; Rev. ____
   SOP for Manual Integration of Chromatographic Peaks; Rev. ____
   SOP for Significant Figures; Rev. ____
   SOP for Corrective Action; Rev. ____
   SOP for Performing Method Detection Limit Studies and Establishing Limits of Detection and Quantitation; Rev. ____

5. Observe performance of SOP — Trainer: ____ Trainee: ____ Date: _____
   ___Standard preparation
   ___Sample preparation (gas-phase dilutions)
   ___Analytical sequence setup
   ___Initial calibration and continuing calibration verification
   ___Sample analysis
   ___EnviroQuant introduction
   ___Data reduction and reporting

6. Perform SOP with supervision — Trainer: ____ Trainee: ____ Date: _____
   ___Standard preparation
   ___Sample preparation (gas-phase dilutions)
   ___Analytical sequence setup
   ___Initial calibration and continuing calibration verification
   ___Sample analysis
   ___EnviroQuant use
   ___Data reduction and reporting

7. Independent performance of the SOP — Trainer: ____ Trainee: ____ Date: _____
   ___Sample preparation (gas-phase dilutions)
   ___Standard preparation
   ___Analytical sequence setup
   ___Initial calibration and continuing calibration verification
   ___Sample analysis
   ___EnviroQuant proficiency
   ___Data reduction and reporting
   ___Initial demonstration of competency (selection is at the discretion of the QAPM)
   ___ Method Detection Limit Study; or
   ___ Four consecutive laboratory control samples; or

8. Instrument operation and maintenance — Trainer: ____ Trainee: ____ Date: _____
   - Gas chromatograph and column installation (packed)
   - Detector (TCD) setup and maintenance
   - Data system

Attachment B

Initial Calibration Checklist
(EPA Method 3C / ASTM D 1946)

Analysis: *EPA Method 3C / ASTM D 1946*
ICAL Date: _____
Instrument: ☐ GC 1 ☐ GC ____

Initial Calibration Checklist (Fixed Gases)

Analyst **Reviewer**

☐ 1. Is the required documentation in the ICAL file? ..... ☐
- ☐ Sequence report
- ☐ Blank analysis Quantitation Report
- ☐ Calibration Status Report (aka Calibration History) - Initial
- ☐ Response Factor Report & Plot for Hydrogen
- ☐ Quantitation Report for each calibration standard (including manual integration documentation – before and after printouts)
- ☐ ICV Quantitation Report and Evaluate Continuing Calibration Report (aka Percent Diff. report)

☐ 2. Was the ICAL performed continuously (i.e., not interrupted for maintenance or for sample analysis) ..... ☐

☐ 3. Have all the calibration standards been analyzed within 48 hours of each other? ..... ☐

☐ 4. Were the standards analyzed from low concentration to high concentration? ..... ☐

☐ 5. Are all the analytes in the blank analysis < MRL? ..... ☐

☐ 6. Does each analyte's ICAL include a minimum of 5 consecutive concentrations? ..... ☐

☐ 7. Was each standard concentration included in the ICAL? ..... ☐

☐ 8. If a point is dropped, is information noted in the ICAL explaining the reason? ..... ☐

☐ 9. Does this follow the CAS point dropping policy? Are the injections dropped for that concentration for each analyte? ..... ☐

☐ 10. For each analyte, is the lowest standard's concentration at or below the analyte's MRL? ..... ☐

☐ 11. For each analyte, are there no levels skipped? ..... ☐

☐ 12. For analytes calibrated using average RF, is the RSD ≤15%? For hydrogen ≥0.99? ..... ☐

☐ 13. For the ICV analysis is the percent recovery for each analyte 85 - 115%? ..... ☐

☐ 14. Are all peak integrations including manual integrations (per SOP on manual integrations) acceptable? ..... ☐

If so, initial and date the appropriate pages.

COMMENTS

Analyst: _____ Secondary Reviewer: _____
Date: _____ Date: _____

Attachment C

Data Review Checklist
(EPA Method 3C / ASTM D 1946)

Fixed Gases per EPA Method 3C / ASTM D 1946
Data Review Checklist
(Note exceptions in Comments Section and attach Nonconformity and Corrective Action Reports as appropriate)

Analysis Date: _____ Instrument: ☐ GC 1 ☐ GC ____
Client: _____ QC level: _____
CAS Project #: _____ Due Date: _____
Modification: ☐ Yes ☐ No

Analyst **Reviewer**

Initial Calibration:

☐ 1. Is the referenced ICAL the most recent ICAL performed? NA
☐ 2. Has the referenced ICAL been peer reviewed and all associated documentation including the ICAL review checklist available for review? NA
☐ 3. Were all associated requirements within the specified limits? NA

Data:

☐ 1. Is the sample data documentation present and correct? ☐
___Sample raw data?
___All target analyte responses within calibration range?
___All peak integrations acceptable?
___All manual integrations flagged and documented (before and after)?
If so, initial and date.
___All retention times within limits?
- peak within the generated RT window?
___All calculations correct?
___First quantitation report initialed and dated by analyst?

☐ 2. Do all sample duplicate injections (if analyzing without modification) have a RSD ≤5%? ☐
☐ 3. Does the CCV have a percent difference of ≤10% (≤15% for hydrogen)? ☐
☐ 4. Is the retention time (for CCV) for each analyte in the std. within 0.33min. from the mean RT (of the corresponding analyte) from the ICAL? ☐
☐ 5. Is the sum of the gases in the lab air within 90% and 110%? ☐
☐ 6. Are the %R for the LCS within the acceptance criteria for each analyte? ☐
☐ 7 Are all the analytes in the MB <MRL? ☐
☐ 8. Do all reported analytes fall within the generated retention time windows? ☐
If not is the reason for reporting analyte in the sample documented? ☐
☐ 9. Is the RPD(with modification) for the LD within the laboratory-generated RPD limits? ☐
☐ 10. **DOD:** Are manual integrations notated in the case narrative? ☐

COMMENTS:

Analyst: _____ Secondary Reviewer: _____
Date: _____ Date: _____

Attachment D

Target Analytes with Associated Reporting Limits and Laboratory Control Sample Recovery and Laboratory Duplicate Control Limits (EPA Method 3C / ASTM D 1946)

Target Analytes with Associated MRLs

Compound	Method Reporting Limit
Hydrogen	1000ppm
Nitrogen	1000ppm
Oxygen	1000ppm
Carbon monoxide	1000ppm
Carbon dioxide	1000ppm
Methane	1000ppm

CONTROL LIMITS
(Modified EPA 3C – Single Injection)

Analyte	LCS-LCL (%R)	LCS-UCL (%R)	LD (RPD)
Hydrogen - H_2	83	122	17
Oxygen - O_2	74	132	19
Nitrogen - N_2	76	126	19
Carbon monoxide - CO	84	113	18
Methane - CH_4	84	113	18
Carbon dioxide - CO_2	87	117	19

Note: New limits may be established prior to the revision of this document, refer to the most recent control limits.

Attachment E
Calibration Curve Concentrations

Calibration Curve Concentrations (ppm unless noted as %)						
ICAL	Hydrogen	Oxygen	Nitrogen	Carbon Monoxide	Methane	Carbon Dioxide
1	373.69	467.11	466.18	470.85	373.69	467.11
2	2000	2500	2495	2520	2000	2500
3	7473.77	9342.21	9342.21	9379.58	7511.14	9323.53
4	40000	50000	50000	50200	40200	49900
5	467731.47	584664.34	584664.34	587002.99	470070.13	583495
6	99.999%					
7		99.999%				
8			99.999%			
9					99.999%	
10						99.999%

ICAL	**Amount of standard spiked onto instrument**
1	small loop injection of a 2500ppm/2000ppm standard [1,2]
2	standard loop injection of a 2500ppm/2000ppm standard [1,2]
3	small loop injection of a purchased 5% /4% standard (see section 8.2.1.1) [2]
4	standard loop injection of a purchased 5% /4% standard (see section 8.2.1.1) [2]
5	large loop injection of a purchased 5% /4% standard (see section 8.2.1.1) [2]
6 through 10	Standard loop injection of neat gas compounds (see section 8.2.1.1)

[1]2500ppm/2000ppm standard is made by introducing 600 ml of a purchased 5% /4% standard into a 6 liter summa canister and pressurized to +14.7psig (29.4psi) with helium.
[2]The loop injection volumes are calculated as described in section 21.1.1 and shown in Table 1.

Calibration Range	
Hydrogen	1000ppm – 99.999%
Oxygen	1000ppm – 99.999%
Nitrogen	1000ppm – 99.999%
Carbon Monoxide	1000ppm – 58.700%
Methane	1000ppm – 99.999%
Carbon Dioxide	1000ppm – 99.999%

B4. Extractive Hydrogen Fluoride Sampling and Analysis NMAM Method 7903: Acids, Inorganic

(1) HF; (2) HCl; (3) H_3PO_4; (4) HBr; (5) HNO_3; (6) H_2SO_4 MW: Table 1 CAS: Table 1 RTECS: Table 1

METHOD: 7903, Issue 2 **EVALUATION: FULL** **Issue 1: 15 February 1984**
Issue 2: 15 August 1994

OSHA : Table 1
NIOSH: Table 1
ACGIH: Table 1

PROPERTIES: Table 1

SYNONYMS: (1) hydrofluoric acid; hydrogen fluoride
(2) hydrochloric acid; hydrogen chloride
(3) phosphoric acid; ortho-phosphoric acid; meta-phosphoric acid
(4) hydrobromic acid; hydrogen bromide
(5) nitric acid; aqua fortis
(6) sulfuric acid; oil of vitriol

SAMPLING

SAMPLER: SOLID SORBENT TUBE (washed silica gel, 400 mg/200 mg with glass fiber filter plug)

FLOW RATE: 0.2 to 0.5 L/min

VOL-MIN: 3 L
-MAX: 100 L

SHIPMENT: routine

SAMPLE STABILITY: stable at least 21 days @ 25 °C [1]

BLANKS: 2 to 10 field blanks per set

ACCURACY

RANGE STUDIED: see EVALUATION OF METHOD

BIAS: see EVALUATION OF METHOD

OVERALL PRECISION ($\hat{S}_{rT}$): see EVALUATION OF METHOD

ACCURACY: ± 12 to ± 23%

MEASUREMENT

TECHNIQUE: ION CHROMATOGRAPHY

ANALYTE: F^-, Cl^-, PO_4^{3-}, Br^-, NO_3^-, SO_4^{2-}

DESORPTION: 10 mL 1.7 mM $NaHCO_3$/1.8 mM Na_2CO_3

INJECTION LOOP VOLUME: 50 µL

ELUENT: 1.7 mM $NaHCO_3$/1.8 mM Na_2CO_3; 3 mL/min

COLUMNS: HPIC-AS4A anion separator, HPIC-AG4A guard, anion micro membrane suppressor [2]

CONDUCTIVITY SETTING: 10 µS full scale

RANGE: see EVALUATION OF METHOD

ESTIMATED LOD: see EVALUATION OF METHOD

PRECISION ($\bar{S}_r$): see EVALUATION OF METHOD

APPLICABILITY: The working range is ca. 0.01 to 5 mg/m^3 for a 50-L air sample (see EVALUATION OF METHOD). This method measures the total concentration of six airborne anions. The corresponding acids may be collected on a single sam pler and determined simultaneously. Formic acid has been determined by this method [3].

INTERFERENCES: Particulate salts of all the acids will give a positive interference. Chlorine or hypochlorite ion interfere with chloride determination and bromine interferes with bromide. Silica gel will collect ca. 30% of the free Cl_2 and Br_2 in an atmosphere [4]. Acetate, formate and propionate have elution times similar to F^- and Cl^-. If these anions are present, use a weak eluent (e.g., 5 mM $Na_2B_4O_7$) for greater resolution.

OTHER METHODS: This is P&CAM 339 in a revised format [5]. Alternate methods are 7902 for fluoride and P&CAM 268 for sulfate [6].

REAGENTS:

1. $NaHCO_3$, reagent grade.
2. Na_2CO_3, reagent grade.
3. Distilled, deionized water, filtered through 0.45-µm membrane filter.
4. Eluent: bicarbonate/carbonate buffer solution (1.7 mM $NaHCO_3$/1.8 mM Na_2CO_3). Dissolve 0.5712 g $NaHCO_3$ and 0.7631 g Na_2CO_3 in 4 L filtered deionized water.
5. Calibration stock solutions, 1 mg/mL (as the anion). Dissolve salt in filtered deionized water.
   a. Fluoride: 0.2210 g NaF/100 mL.
   b. Chloride: 0.2103 g KCl/100 mL.
   c. Phosphate: 0.1433 g KH_2PO_4/100 mL.
   d. Bromide: 0.1288 g NaBr/100 mL.
   e. Nitrate: 0.1371 g $NaNO_3$/100 mL.
   f. Sulfate: 0.1814 g K_2SO_4/100 mL.

* See SPECIAL PRECAUTIONS.

EQUIPMENT:

1. Sampler: glass tube, 11 cm x 7-mm OD, containing a 400-mg front section and 200-mg backup section of washed silica gel, flame-sealed ends with plastic caps. Front section is retained with a glass fiber filter plug. Urethane plugs separate and retain the backup section. Tubes are commercially available (Supelco ORBO 53 or equivalent) or may be prepared according to APPENDIX.
2. Personal sampling pump, 0.2 to 0.5 L/min, with flexible connecting tubing.
3. Ion chromatograph, HPIC-AG4A anion separator and HPIC-AG4A anion micro membrane suppressor, conductivity detector, integrator and strip chart recorder.
4. Waterbath: hotplate with beaker of boiling water.
5. Centrifuge tubes, 15-mL, graduated, plastic, with caps.*
6. Syringes, 10-mL, polyethylene with luer tip.
7. Filters, luer tip, with membrane filter, 13-mm, 0.8-µm pore size.
8. Micropipettes, disposable tips.
9. Volumetric flasks, 50- and 100-mL.*
10. Laboratory timer.
11. Bottles, polyethylene, 100-mL.
12. Auto sampler vials (optional).

* Thoroughly clean glassware with mild detergent, rinse thoroughly with deionized water, to minimize anion blank values.

SPECIAL PRECAUTIONS: Acids, particularly HF, are extremely corrosive to skin, eyes, and mucous membranes. HF will attack glass. Plastic labware is recommended.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. Break ends of sampler immediately before sampling. Attach sampler to personal sampling pump with flexible tubing.
3. Sample at an accurately known flow rate between 0.2 and 0.5 L/min for a total sample size of 3 to 100 L.
   NOTE: Do not exceed 0.3 L/min when sampling for HF.

SAMPLE PREPARATION:

4. Score sampler with a file in front of primary sorbent section.
5. Break sampler at score line. Transfer glass fiber filter plug and front sorbent section to a 15-mL graduated centrifuge tube.

NOTE: Particulate salts of the volatile acids (HCl, HB, HF, and HNO_3), if present in the air sample, will collect on the glass fiber filter plug. To estimate the concentration these salts, analyze the plug separately from the front sorbent section.

6. Place backup sorbent section in separate centrifuge tube. Discard urethane plugs.
7. Add 6 to 8 mL eluent to each centrifuge tube. Heat in boiling waterbath for 10 min.
   NOTE: Eluent used for desorption should be from same batch as the eluent used in the chromatograph to avoid carbonate/bicarbonate peaks near F^- and Cl^-.
8. Allow to cool, dilute to 10.0-mL volume with eluent.
9. Cap the centrifuge tube and shake vigorously.
10. Pour sample into 10-mL plastic syringe fitted with in-line filter.

CALIBRATION AND QUALITY CONTROL:

11. Calibrate daily with at least six working standards covering the range 0.001 to 0.3 mg of each anion per sample.
    a. Add known aliquots of calibration stock solution to eluent in 50-mL volumetric flasks and dilute to the mark.
    b. Store working standards in tightly-capped polyethylene bottles. Prepare fresh working standards weekly.
    c. Analyze working standards together with samples and blanks (steps 12 through 14).
    d. Prepare a calibration graph for each anion [peak height (mm or µS) vs. concentration (µg per sample)].

MEASUREMENT:

12. Set ion chromatograph to conditions given on page 7903-1, according to manufacturer's instructions.
13. Inject 50-µL sample aliquot. For manual operation, inject 2 to 3 mL of sample from filter/syringe to ensure complete rinse of sample loop.
    NOTE: All samples, eluents and water flowing through the IC must be filtered to avoid plugging system valves or columns.
14. Measure peak height.
    NOTE: If sample peak height exceeds linear calibration range, dilute with eluent, reanalyze and apply the appropriate dilution factor in calculations.

CALCULATIONS:

15. Determine the mass, µg, of anion found in the sample front (W_f) and back (W_b) sorbent sections, and in the average media blank front (B_f) and back (B_b) sorbent sections.
16. Calculate concentration, C, of acid in the air volume sampled, V (L):

$$C = \frac{(W_f + W_b - B_f - B_b) \cdot F}{V}, \text{ mg/m}^3.$$

where: F (conversion factor from anion to acid) = 1.053 for HF; 1.028 for HCl; 1.032 for H_3PO_4; 1.012 for HBr; 1.016 for HNO_3; and 1.021 for H_2SO_4.

EVALUATION OF METHOD:

The method was evaluated for hydrochloric, hydrobromic, nitric, phosphoric and sulfuric acids by laboratory generation of mixed acids [1]. Data for the individual analytes are:

Acid	Range Studied (mg/m^3)	Range Studied (µg/sample)	(%)	Measurement Precision ($\bar{S}_r$)	Overall Precision ($\hat{S}_{rT}$)	Accuracy (%)	Estimated LOD [2] (µg per sample)
HF [7]	0.35 - 6	0.5 - 200	0.7	0.053	0.116	±23.4	0.7
HCl [8]	0.14 - 14	0.5 - 200	0.3	0.025	0.059	±11.9	0.6
H_3PO_4 [1]	0.5 - 2	3 - 100	-0.9	0.029	0.096	±19.7	2.0
HBr [1]	2 - 20	3 - 960	2.0	0.056	0.074	±16.5	0.9
HNO_3 [1]	1 - 10	3 - 500	2.0	0.018	0.085	±18.7	0.7
H_2SO_4 [1]	0.5 - 2	3 - 100	2.4	0.028	0.087	±19.4	0.9

The method was field-evaluated at two electroplating facilities using side-by-side silica gel tubes and bubblers. The method was evaluated for hydrofluoric acid in 1983 using the silica gel tubes and impingers [7]. Recovery based on impinger collection was 106% with $\hat{S}_{rT}$ of 0.116. The capacity of the silica gel sampler for HF was 820 µg. This is equivalent to an 8-h sample at two to three times the OSHA PEL. Samples were stable for at least 21 days at 25 °C. Updated analytical columns have been used by NIOSH for analytical sequences [2].

REFERENCES:

[1] Cassinelli, M. E. and D. G. Taylor. Airborne Inorganic Acids, ACS Symposium Series 149, 137-152 (1981).
[2] DataChem, Inc. NIOSH Analytical Sequences #7546, #7357, and #7594 (unpublished, 1992).
[3] DataChem Laboratories, NIOSH Sequence #7923-C,D (unpublished, Jan. 25, 1994).
[4] Cassinelli, M.E. "Development of a Solid Sorbent Monitoring Method for Chlorine and Bromine in Air with Determination by Ion Chromatography." Appl. Occup. Environ. Hyg. 6:215-226 (1991)
[5] NIOSH Manual of Analytical Methods, 2nd. ed., V. 7, P&CAM 339, U.S. Department of Health and Human Services, (NIOSH) Publication No. 82-100 (1982).
[6] NIOSH Manual of Analytical Methods, 2nd. ed., V. 5, P&CAM 268, U.S. Department of Health and Human Services, (NIOSH) Publication No. 82-100 (1982).
[7] Cassinelli, M. E. "Laboratory Evaluation of Silica Gel Sorbent Tubes for Sampling Hydrogen Fluoride," Am. Ind. Hyg. Assoc. J., 47(4):219-224 (1986).
[8] Cassinelli, M. E. and P. M. Eller. Ion Chromatographic Determination of Hydrogen Chloride, Abstract No. 150, American Industrial Hygiene Conference, Chicago, IL (1979).

METHOD WRITTEN BY:

Mary Ellen Cassinelli, NIOSH/DPSE.

APPENDIX: SAMPLING TUBE PREPARATION

Silica gel cleaning procedure: Add 500 to 600 mL deionized water, slowly and with stirring, to ca. 200 mL volume of silica gel in 1-L beaker. When exothermal reaction has subsided, heat in boiling waterbath for ca. 30 min with occasional stirring. Decant and rinse four to five times with deionized water. Repeat cleaning procedure and dry overnight in 100 °C oven until free flowing. If blank of silica gel shows impurities upon analysis by ion chromatography, repeat cleaning procedure.

Silica gel tubes: Pack glass tubes, 7-mm OD, 4.8-mm ID, 11 cm long, with 400 mg of 20/40 mesh washed silica gel in front section and 200 mg backup section. Use urethane foam plugs between sorbent sections and at back end. Hold front section in place with 6-mm diameter, 1-mm thick glass fiber filter plug (Gelman 66088).

TABLE 1. GENERAL INFORMATION.

Acid	PROPERTIES and BP M.W. (°C)	CAS Sp. Gr. RTECS (liq.)	EXPOSURE LIMITS VP @ 20 °C OSHA kPa (mm Hg)	NIOSH	ACGIH	mg/m^3 = 1 ppm @ NTP	Physical State	MP (°C)
HF	19.5 (20.01)	7664-39-3 0.987 MW7875000	3 ppm >101 (>760)	3 ppm; 6 ppm STEL	C 3 ppm;	0.818	gas	-83.1
HCl	-114.8 (36.46)	7647-01-0 -85.0 MW4025000	C 5 ppm 1.194	C 5 ppm >101 (760)	C 5 ppm	1.491	gas	
H_3PO_4	260 (97.99)	7664-38-2 1.7 TB6300000	1 mg/m^3 0.0038 (0.03)	1 mg/m^3;* STEL 3 mg/m^3	1 mg/m^3; STEL 3 mg/m^3	(aerosol)	liquid	21.0
HBr	-66.8 (80.92)	10035-10-6 2.16 MW3850000	3 ppm >101 (>760)	C 3 ppm	C 3 ppm	3.31	gas	-88.5
HNO_3	-42.0 (63.01)	7697-37-2 83 QU5775000	2 ppm 1.50	2 ppm; 0.39 (2.9) STEL 4 ppm	2 ppm; STEL 4 ppm	2.58	liquid	
H_2SO_4	290 (98.08)	7664-93-9 1.84 W55600000	1 mg/m^3 <0.0001 (<0.001)	1 mg/m^3*	1 mg/m^3 STEL 3 mg/m^3	(aerosol)	liquid	3.0

*Group I Pesticide

B5 Extractive Hydrogen Cyanide Sampling and Analysis

B5.a. NMAM Method 6010: Hydrogen Cyanide

HCN MW: 27.03 CAS: 74-90-8 RTECS: MW6825000

METHOD: 6010, Issue 2 **EVALUATION: FULL** **Issue 1: 15 May 1989**
Issue 2: 15 August 1994

OSHA : 10 ppm (skin)
NIOSH: STEL 4.7 ppm
ACGIH: C 10 ppm (skin)
(1 ppm = 1.105 mg/m^3 @ NTP)

PROPERTIES: gas; BP 26 °C; vapor density 0.93 (air = 1.00); d(liq) 0.69 g/mL @ 20 °C; VP 82.7 kPa (620 mm Hg) @ 20 °C; explosive range 5 to 40% v/v in air

SYNONYMS: hydrocyanic acid, prussic acid, formonitrile

SAMPLING

SAMPLER: SOLID SORBENT TUBE (soda lime, 600 mg/200 mg)

FLOW RATE: 0.05 to 0.2 L/min

VOL-MIN: 2 L @ 5 ppm
-MAX: 90 L

SHIPMENT: routine

SAMPLE STABILITY: at least 2 weeks @ 25 °C [1]

BLANKS: 2 to 10 field blanks per set

ACCURACY

RANGE STUDIED: 2 to 15 mg/m^3 [1] (3-L samples)

BIAS: Not significant

OVERALL PRECISION ($\hat{S}_{rT}$): 0.076 [1]

ACCURACY: ± 15.0%

MEASUREMENT

TECHNIQUE: SPECTROPHOTOMETRY, VISIBLE ABSORPTION

ANALYTE: cyanide ion complex

DESORPTION: 10 mL deionized water; stand 60 min

COLOR DEVELOPMENT: N-chlorosuccinimide/ succinimide oxidizing agent and barbituric acid/pyridine coupling agent; absorption @ 580 nm in 1-cm cuvette

CALIBRATION: standard solutions of KCN in 0.1 N NaOH

RANGE: 10 to 300 µg CN^- per sample [1]

ESTIMATED LOD: 1 µg CN^- per sample [1]

PRECISION ($\hat{S}_r$): 0.041 @ 10 to 50 mg per sample [1]

APPLICABILITY: The working range is 0.3 to 235 ppm (3 to 260 mg/m^3) for a 3-L air sample. This method is applicable to STEL measurements. Particulate cyanides are trapped by the initial glass fiber membrane disk. This method is more sensitive and subject to fewer interferences than NIOSH Method 7904, which uses ion specific electrode analysis. The method was used to determine HCN in firefighting environments [2].

INTERFERENCES: A high concentration of hydrogen sulfide gives a negative interference.

OTHER METHODS: This is based on the method of Lambert, et al. [3]. NIOSH Method 7904 uses an ion specific electrode for measurement. The method has been adapted for use with a Technicon Autoanalyzer [4].

REAGENTS:

1. Potassium cyanide*, reagent grade.
2. Succinimide, reagent grade.
3. N-Chlorosuccinimide, reagent grade.
4. Barbituric acid, reagent grade.
5. Pyridine, spectrophotometric quality.
6. Phenolphthalein, 1% (w/v) in ethanol or methanol, reagent grade.
7. Hydrochloric acid, concentrated, reagent grade.
8. Sodium hydroxide (NaOH), reagent grade.*
9. Sodium lime (CaO + 5-20% NaOH), reagent grade (Aldrich #26,643-4 or equivalent). Crush and sieve to 10/35 mesh. Store in capped container.*
10. Water deionized-distilled.
11. Sodium hydroxide solution, 0.1 N.*
12. Calibration stock solution. 1 mg /mL CN^-. Dissolve 0.125 g KCN in 0.1 N NaOH in a 50-mL volumetric flask. Dilute to mark with 0.1 N NaOH. Standardize by titration with standard $AgNO_3$ solution (see APPENDIX).
13. Hydrochloric acid solution, 0.15 N.
14. N-Chlorosuccinimide/succinimide oxidizing reagent. Dissolve 10.0 g succinimide in about 200 mL distilled water. Add 1.00 g N-chlorosuccinimide. Stir to dissolve. Adjust volume to 1 liter with distilled water. Stable 6 months when refrigerated.
15. Barbituric acid/Pyridine reagent. Add about 30 mL distilled water to 6.0 g barbituric acid in a 100-mL Erlenmeyer flask. Slowly add 30 mL pyridine with stirring. Adjust the volume to 100 mL with water. Stable 2 months when refrigerated.

EQUIPMENT:

1. Sampler, glass tube, 9 cm long, 7-mm OD, 5-mm ID, with plastic caps, containing two sections (front = 600 mg; back = 200 mg) granular soda lime 10/35 mesh, separated and contained with silanized glass wool plugs, with a 5-mm diameter glass fiber filter disk placed before the plug on inlet side. Tubes are commerically available. (SKC, Inc. 226-28 or equivalent.)
2. Spectrophotometer, visible, 580 nm, with cuvettes, 1-cm light path.
3. Personal sampling pump, 0.05 to 0.2 L/min, with flexible connecting tubing.
4. Pipets, volumetric 0.1-, 0.5-, 1.0-, 2.0-, 10.0-mL.
5. Vials, glass or plastic, 15-mL with PTFE-lined caps.
6. Flasks, volumetric, 25-, 50-, 100-, 1000-mL, with stoppers.
7. Pipets, transfer, disposable.
8. Syringes, 10-µL, readable to 0.1 µL.
9. Flask, Erlenmeyer, 100-mL.
10. Syringes, 10-mL, polyethylene with luer tip.
11. Filter cassette, with membrane filter, 13-mm diameter, 0.45-µm pore size, with luer fitting.

* See SPECIAL PRECAUTIONS

SPECIAL PRECAUTIONS: HCN gas and cyanide particulates are highly toxic and may be fatal if swallowed, inhaled, or absorbed through the skin [5]. Soda lime and NaOH are very caustic [5]. Use gloves and a fume hood for handling these chemicals.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. Break ends of sampler immediately before sampling. Attach sampler to personal sampling pump with flexible tubing.
3. Sample at an accurately known flow rate between 0.05 and 0.2 L/min for a total sample size of 0.6 to 90 L.
4. Cap tube. Pack securely for shipment.

SAMPLE PREPARATION:

5. Score each sampler with a file. Break sampler at score line.
6. Transfer front and back sorbent sections to separate vials. Discard glass wool plugs separating and retaining sorbent sections.
   NOTE: An estimate of particulate cyanide may be obtained by analyzing the initial glass fiber filter disk as follows; however, no evaluation data are available for particulate cyanides determined in this manner.
   (i) Transfer the glass wool plug at the tube inlet and the glass fiber filter disk immediately behind it to a third vial.
   (ii) Add 10.0 mL 0.1 N NaOH to each vial.
   (iii) Proceed with step 8.
7. Add 10.0 mL deionized-distilled water to each vial containing a sorbent section. Cap each vial.
8. Allow to stand 60 minutes, with occasional agitation. Transfer to a 10-mL plastic syringe fitted with an in-line 0.45-µm filter. Collect the filtrate in a clean vial.

CALIBRATION AND QUALITY CONTROL:

9. Calibrate daily with at least six working standards over the range 1 to 300 µg CN^- per sample.
   a. Prepare a working standard solution, 1.00 µg /mL.CN^-, by diluting 100 µL of calibration stock solution to 100 mL with 0.1 N NaOH.
   b. Pipet 0.5-, 1.00-, 1.50-, 2.00- and 2.50-mL of the working standard solution into 25-mL volumetric flasks to make 0.50-, 1.00-, 1.50-, 2.00- and 2.50- µg CN^- standards.
   c. Analyze together with field samples and blanks (steps 12 through 19).
   d. Prepare calibration graph (absorbance vs. µg CN^-).
10. Determine desorption efficiency (DE) at least once for each lot of soda lime used for sampling. Prepare at least three tubes at each of five levels plus three media blanks.
   a. Remove and discard back sorbent section of a blank sampler.
   b. Inject a known amount of calibration stock solution directly onto the soda lime with a microliter syringe.
   c. Cap, and allow to stand overnight.
   d. Desorb (steps 5 through 8) and analyze together with working standards and blanks (steps 12 through 19).
   e. Prepare a graph of DE vs. µg CN^- recovered.
11. Analyze three quality control blind spikes and three analyst spikes to ensure that the calibration graph and DE graph are in control.

MEASUREMENT:

12. Set spectrophotometer according to manufacturer's recommendations and to conditions on p. 6010-1.
13. Pipet a sample aliquot estimated to contain 0.5 to 2.5 µg CN^- into a 25-mL volumetric flask. Alternately, to cover an unknown sample concentration range, pipet 0.5-, 1.00-, and 3.00-mL aliquots into separate 25-mL vol. flasks for each field sample. Larger or smaller aliquots may be taken, based on prior knowledge of expected analyte level.
14. Pipet 0.5 mL 0.1 N NaOH into a 25-mL volumetric flask for reagent blank.
15. Add one drop phenolphthalein solution to each standard or sample.
   NOTE: Add a little deionized-distilled water to increase volume for easier mixing. All solutions should be alkaline (pink) at this point.
16. Starting with the reagent blank, add dropwise 0.15 N HCl, with mixing, until pink color just disappears. CAUTION: HCN may be produced. Work in hood. Immediately add 1.0 mL N-chlorosuccinimide/succinimide oxidizing reagent. Mix and let stand.

NOTE 1: To avoid possible loss of HCN, add the oxidizing agent before proceeding to the next sample.

NOTE 2: Do not prepare more samples than can be analyzed within the 30-minute maximum time for color development.

17. After at least 5 min. standing (but not longer than 15 min), starting with the reagent blank, add 1.0-mL barbituric acid-pyridine coupling reagent. Mix.
18. Adjust sample volume to 25 mL with deionized-distilled water and allow to stand at least 12 min (but not longer than 30 min) for color development.
19. Read absorbance at 580 nm in a 1-cm light path cuvette on a spectrophotometer. If sample absorbance is outside the range of the calibration standards, take an aliquot, re-analyze (steps 12 through 19), and apply the appropriate aliquot factor in calculations.

CALCULATIONS:

20. Calculate the mass, µg, of CN^- in aliquot analyzed. Apply the appropriate aliquot factor to calculate the mass, µg, of CN^- in the original 10-mL solution.
21. Determine the mass, µg CN^- (corrected for DE), found in the sample front (W_f) and back (W_b) sorbent sections and in the average media blank front (B_f) and back (B_b) sorbent sections. If $W_b > W_f/10$, report breakthrough and possible sample loss.
22. Calculate concentration, C, of HCN in the air volume sampled, V(L).

$$C = \frac{(W_f + W_b - B_f - B_b) \cdot 1.039}{V}, \text{ mg/m}^3.$$

where 1.039 = conversion factor, CN^- to HCN

EVALUATION OF METHOD:

The method was evaluated by sampling the test atmospheres of HCN generated from a compressed mixture of HCN in nitrogen [1]. The range of HCN concentration was equivalent to 2 to 15 mg/m^3 for a 3-L air sample. Twenty-two samples collected at 0.2 L/min for 15 minutes indicated overall precision $\hat{S}_{rT}$ of 0.076 with nearly 100% recovery. Breakthrough occurred after 40 minutes of sampling at the flow rate of 0.2 L/min at an HCN concentration of 148 mg/m^3. Sample tubes spiked with solutions of KCN and analyzed after storage, indicated that the samples of cyanide ions were stable on the tube for at least 2 weeks. Analysis of 22 tubes which were spiked with KCN standard solutions in the range 10 to 50 µg indicated a recovery of nearly 100% with a pooled precision of 0.041. Desorption efficiency may be poor below 10 µg CN^- [6].

REFERENCES:

[1] Williamson, George. "Method Development Protocol and Backup Data Report on Hydrogen Cyanide"
Internal NIOSH/MRSB Report, Unpubl. NIOSH (1988).
[2] Williamson, George. "Analysis of Air Samples on Project 166 (Firesmoke) on HCN; Sequence NIOSH/MRSB-6366A, Unpubl. NIOSH, (1988).
[3] Lambert, J. L., Ramasamy, J., and J. V. Paukstelis, "Stable Reagents for the Colorimetric Determination of Cyanide by Modified Konig Reactions," Analyt. Chem., 47, 916-918 (1975).
[4] DataChem Laboratories, NIOSH Sequence #6837-K (unpublished, March 21, 1990).
[5] NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards, U.S. Department of Health and Human Services. Publ. (NIOSH) 81-123 (1981), available as stock #PB 83-154609 form NTIS, Springfield, VA 22161.
[6] DataChem Laboratories, User Check, NIOSH Sequence #6837-J (unpublished, March 19, 1990).

METHOD WRITTEN BY: George Williamson, NIOSH/DPSE.

APPENDIX: STANDARDIZATION OF CALIBRATION STOCK SOLUTION

Titrate an aliquot of the cyanide standard stock solution (Reagent 12) with standard silver nitrate ($AgNO_3$) solution. The end point is the first formation of a white precipitate, $Ag[Ag(CN)_2]$. Calculate the cyanide concentration with the following equation:

$$M_c = 52.04\ V_a\ (M_a/V_c)$$

Where M_c = cyanide concentration (mg/mL)
V_a = volume (mL) of standard silver nitrate solution
M_a = concentration (moles/L) of standard silver nitrate solution
V_c = volume (mL) of calibration stock solution titrated

B5.b. Datachem Laboratories, Inc. SOP for NIOSH Method 6010 – Modified

DATACHEM LABORATORIES, INC.

STANDARD OPERATING PROCEDURE APPROVAL SHEET

SOP TITLE: NIOSH METHOD 6010 - MODIFIED

DOCUMENT CONTROL NUMBER: NMAM 6010 MOD

EFFECTIVE DATE: February 19, 2008

APPROVALS:

MANAGER _____ Date _____

QA MANAGER _____ Date _____

LAB DIRECTOR _____ Date _____

STANDARD OPERATING PROCEDURE

NMAM 6010 MOD

1.0 SCOPE

This procedure is used for routine industrial hygiene sample preparations and analyses and has been written by DataChem Laboratories Inc. (DCL) to describe how the referenced method is performed by laboratory personnel. Modifications to the referenced method may be necessary to improve the quality of the data generated and/or to accommodate client requests not specifically addressed by the referenced method. This modified method is performed in accordance with the DataChem Industrial Hygiene Quality Assurance Plan and utilizes the following general Standard Operating Procedures (SOPs) as applicable:

Lab-003 “Labeling of Solutions and Reagents”
Lab-005 “General Laboratory Safety and Chemical Hygiene”
Lab-020 “Nonconformance/Corrective Action (NC/CAR) Procedures”
Lab-022 “Uncertainty”
Lab-030 “Documentation: Maintaining Instrument Records, Notebooks and Logbooks”
Lab-031 “Documentation of Modified Methods and Validation of Permanently Modified and New Analytical Methods”
IH-QA-010 “General Calibration Protocol for Inorganic Analyses of Industrial Hygiene Samples”

Additional SOPs may also be identified which further describe modifications to the referenced method.

2.0 REFERENCE METHOD

2.1 The reference method is written specifically for the analysis of hydrogen cyanide on a soda lime solid sorbent tube.


NMAM 6010

3.0 MODIFICATIONS TO THE REFERENCE METHOD

3.1 DataChem Laboratories utilizes a fully automated discrete wet chemistry analyzer (Westco Scientific SmartChem Discrete Analyzer) in the performance of this method. The discrete analyzer provides automated functions for pipetting, standards preparation, dilutions, and cuvette washing while also allowing major reductions in the volumes of samples and chemical reagents necessary to perform the instrumental analysis. Accordingly, the instrument manufacturer’s instructions for performing the chemical analyses are followed with respect to the specific reagents, concentrations, and volumes necessary to ensure reliable quantitation. The following modifications to the reference method are therefore employed:

3.1.1 The following reagents specified by the reference method are not utilized: succinimide, N-chlorosuccinimide, 0.15 N hydrochloric acid, 0.1 N sodium hydroxide, and phenolphthalein.

3.1.2 The instrument manufacturer's instructions are followed for adding 1 mL aliquots of concentrated Probe Rinse (Westco Part Number 3AS-RN00-21) to the barbituric acid/pyridine color reagent (3.1.3) and the 1 M sodium phosphate buffering solution (3.1.5).

3.1.3 The barbituric acid/pyridine color reagent is prepared as follows: add approximately 100 mL distilled-deionized (DDI) water to15 g barbituric acid in a 1 liter volumetric flask. Slowly add 75 mL pyridine while mixing well. Then add 1 mL of concentrated Probe Rinse (Westco Part Number 3AS-RN00-21) and 15 mL concentrated hydrochloric acid. Mix well, cool to room temperature, and bring to 1 liter final volume with DDI water.

3.1.4 The chloramine-T reagent solution ($CH_3C_6H_4SO_2N(Cl)Na \cdot xH_2O$) specified by the instrument manufacturer is prepared daily by adding 0.25 g of chloramine-T (N-chloro-p-toluene sulfonamide sodium salt) to 25 mL of DDI water.

3.1.5 The 1 M sodium phosphate buffering solution specified by the instrument manufacturer is prepared by adding 138 g $NaH_2PO_4 \cdot H_2O$ and 1 mL of concentrated Probe Rinse (Westco Part Number 3AS-RN00-21) to 1 liter of DDI water.

3.2 DataChem Laboratories utilizes purchased potassium cyanide standard solutions.

3.3 Each sorbent tube section is desorbed in 20 mL of 0.25 N NaOH instead of DDI water in order to matrix-match the prepared samples with the calibration standards. The NaOH reagent is prepared by dissolving 20 g of NaOH pellets to a final volume of 2 liters in DDI water.

3.4 Although both the front and back sections of the sorbent tube are prepared for analysis, only the front section is filtered prior to analysis. The filtration of the front section is performed directly into the sample cup to be analyzed.

3.5 The cyanide method is set up in the instrument software with the following analytical parameters:

Type:	End Point
Direction:	Up
Decimals:	3
Model:	Linear
Filter 1:	570 nm
Sample Blanking:	No
Calibration Code:	CYN

Method Code: CYN	**Volume**	**Delay**	**Read**	**Rinse**	**Code**

Range: 10 to 400 µg (CN)/L		**Time**	**Time**		
Sample Volume	210 µL				
Reagent 1: Sodium phosphate	89 µL	108 sec	0	0	CNSP
Reagent 2: Chloramine T	21 µL	36 sec	0	0	CNCL
Reagent 3: Color reagent	210 µL	0	576 sec	0	CNPY

3.6 The instrument is calibrated using a single set of working calibration standards automatically prepared by the instrument from serial dilutions of a 500 ug/L standard which is prepared by the analyst. The calibration standards range in concentration from 10 ug/L to 400 ug/L. The initial calibration is verified by the preparation and analysis of an independent check standard having a concentration near the mid-point of the calibration range. Verification of continuing calibration throughout the run is demonstrated by reanalysis of the mid-range calibration standard after every 10 samples and at the end of the analytical run.

3.7 The desorption efficiency for each lot of sorbent tubes used to collect the field samples is not determined.

3.8 For quality control purposes, a media blank and a duplicate pair of spiked media blanks are prepared for each analytical batch containing a maximum of 20 field samples. The analyst prepares the duplicate spikes using an independent cyanide stock from the one used to prepare the calibration standards.

3.9 A calibration curve is generated by the instrument software and results in ug(CN)/L are automatically calculated from the calibration curve. Results are then reported as ug(HCN)/sample after using the following equation:

(ug(CN)/L) X (0.02L/sample) X (1.039 ug HCN/ugCN) = ug(HCN)/Sample

3.10 Field sample results are not media blank corrected unless specifically instructed to do so by the client.

3.11 Additional references:

3.11.1 Westco Scientific, SmartChem Users' Manual, Chapters 1 through 10.

3.11.2 Westco Scientific, SmartChem Methods Manual, Chapter 6, SmartChem Method #280-400D, "Cyanide, Total in Water, Waste Water and Soil Extracts and Other Aqueous Samples."

B6. SOP for Analysis of Sulfur Compounds in a Gaseous Matrix by Gas Chromatography with Sulfur Chemiluminescence Detection per ASTM D 5504 and Modified SCAQMD Method 307

STANDARD OPERATING PROCEDURE

for

Analysis of Sulfur Compounds in a Gaseous Matrix by Gas Chromatography with Sulfur Chemiluminescence Detection per ASTM D 5504 and Modified SCAQMD Method 307

SOP Code:VOA-S307M_SCD

Revision: 12

Effective Date: March 30, 2012

Approved by:

Wade Henton – VOA GC Team Leader — Date: 3/18/12

Chaney Humphrey – Quality Assurance Program Manager — Date: 3/19/12

Kelly Horiuchi – Laboratory Manager — Date: 03/23/12

2655 Park Center Drive, Suite A
Simi Valley, CA 93065

DOCUMENT CONTROL
NUMBER: Non-Controlled

Initials: _____ Date: _____

Standard Operating Procedure for Analysis of Reduced Sulfur Compounds in a Gaseous Matrix by Gas Chromatography with Sulfur Chemiluminescence Detection per ASTM D 5504 and Modified SCAQMD Method 307

1.0 SCOPE AND APPLICATION

This gas chromatographic procedure is used in the determination of reduced sulfur compounds in a gaseous matrix in accordance with ASTM D 5504-08 and modified SCAQMD Method 307-91. This procedure applies to, but is not limited to the following types of samples: ambient air, landfill gas, source emissions, digester gases, and vehicular exhaust at ppb to high ppm levels. Refer to Attachment D for the specific list and the optional list of sulfur compounds as well as the corresponding method detection and reporting limits. The number of samples, which may be analyzed in one eight hour day, is approximately fifteen.

Certain modifications are included since this method (SCAQMD 307) is intended for high level (ppm) sulfur determinations and a few of the performance criteria (i.e., 10% difference for the continuing calibration verification) are difficult to achieve at low ppb levels. However, procedures/criteria (i.e., six point initial calibration and laboratory control samples) have been implemented to ensure that the expected accuracy of measurements are not compromised.

2.0 METHOD SUMMARY

Samples are introduced into the system using a gas-tight syringe. Reduced sulfur compounds in these gaseous samples are separated by gas chromatography and are combusted in a fuel-rich environment to yield sulfur monoxide and other products (1). The effluent from the combustion furnace is directed to the chemiluminescence analyzer where the sulfur monoxide is reacted with ozone to produce electronically excited sulfur dioxide and oxygen (2). The excited sulfur dioxide relaxes with emission of light in the blue and ultraviolet regions of the spectrum (3). This light is detected with a blue-sensitive photomultiplier tube. Results are quantitated against the initial calibration (ICAL) curve for methyl mercaptan (for analytes not included in the ICAL) or the client may request to have the results reported as total reduced sulfur as hydrogen sulfide.

(1) Sulfur Compound + H_2/Air $\longrightarrow$ SO + products

(2) $SO + O_3 \longrightarrow SO_2^* + O_2$

(3) $SO_2^* \longrightarrow SO_2 + H\nu$

where

$H\nu$ = chemilunisescent light energy.
SO_2^* = electronically excited SO_2

3.0 DEFINITIONS

3.1 Analytical Sequence

The analytical sequence describes exactly how the field and QC samples in an analytical batch are to be analyzed.

3.2 Field Sample

A sample collected and delivered to the laboratory for analysis.

3.3 Batch QC

Batch QC refers to the QC samples that are analyzed in an analytical batch of field samples and includes the Method Blank (MB), Laboratory Control Sample (LCS), or Laboratory Duplicate (LD), etc.

3.4 Calibration Standard (Initial Calibration – ICAL)

A calibration standard is a solution of an analyte at a known concentration prepared from a primary standard solution, which is, in turn, prepared from a stock standard material. A calibration standard is analyzed at varying concentrations and used to calibrate the response of the measurement system with respect to analyte concentration.

3.5 Initial Calibration Verification (ICV) Standard

An ICV is a standard that is prepared from materials obtained from a source other than the source for the calibration standards and is analyzed after the measurement system is calibrated, but prior to sample analysis in order to verify the calibration of the measurement system.

3.6 Method Blank (MB)

An analyte-free matrix, which is carried through the entire analytical process. It is used to evaluate the process for contamination from the laboratory.

3.7 Laboratory Control Sample (LCS)

The LCS is subjected to the same processing as field samples and is carried through the entire analytical process. The percent recovery of the analyte(s) in the LCS is used to assess method performance.

3.8 External Standard Calibration

External standard calibration involves comparison of instrument responses from the sample to the responses from the target compounds in the calibration standards. Sample peak areas or peak heights are compared to peak areas or peak heights of the standards.

3.9 Analytical Batch

A group of samples that behave similarly with respect to the sampling or the test procedures utilized and are processed as a unit using the same lots of reagents and with the same manipulations to each sample within the same time period or in continuous sequential time periods. In an analytical batch of samples, the time period is 24 hours or up to twenty samples injections, whichever comes first of continuous operation without interruption.

3.10 Continuing Calibration Verification (CCV) Standard

A continuing calibration verification standard is a calibration standard that is analyzed periodically to verify the continuing calibration of the measurement system.

3.11 Precision

Precision of a method is how close results are to one another, and is usually expressed by measures such as standard deviation, which describe the spread of results.

3.12 Bias

The bias of a method is an expression of how close the mean of a set of results (produced by the method) is to the true value.

3.13 Manual Integration

This term applies to a data file in which setpoints have been changed and reintegration has occurred under the changed setpoints; baselines have been adjusted; peak integration start and stop “ticks” have been changed; peak area, or peak height, are changed after the time of data collection and data file generation.

3.14 Laboratory Duplicate

A second aliquot of a sample taken from the same container and analyzed.

3.15 May

This action, activity, or procedural step is neither required nor prohibited.

3.16 Must Not

This action, activity, or procedural step is prohibited.

3.17 Must

This action, activity, or procedural step is required.

3.18 Shall

This action, activity, or procedural step is required.

3.19 Should

This action, activity, or procedural step is suggested, but not required.

4.0 INTERFERENCES

4.1 Interfering Compounds

A SCD is one of the most selective sulfur detectors available, with a sulfur-to-carbon selectivity of $>10^7$. Therefore the response of the volatile sulfur compounds is not affected by the co-elution of hydrocarbons in the sample matrix. However, since the SCD will respond to all sulfur-containing compounds, unknown peaks which do not match the retention times of the known standards may interfere with the identification and quantitation of the target analytes if present at comparatively high concentrations.

4.2 Compound Reactions

Loss of sulfur compounds can occur if the sample comes in contact with active sites in syringes, sample containers or injection ports. This can be reduced by silanizing all equipment and apparatus which comes in contact with samples and standards including syringes, injection port liners, and glass dilution bombs and bottles.

4.3 Method Interferences

All glassware associated with this method must be scrupulously cleaned to avoid possible contamination. The cleaning shall be performed in accordance with the procedure outlined in the *SOP for Glassware Cleaning.* The use of high purity water, reagents, and solvents helps to minimize these problems.

4.4 Tedlar Bag Artifacts

Both carbonyl sulfide and carbon disulfide are Tedlar bag artifacts that provide interference, which may result in elevated levels of these compounds. The levels of these compounds are routinely found to be less than the method-reporting limit. In order to substantiate reporting confidence for both carbonyl sulfide and carbon disulfide, no result

will be reported to the client at levels below the method reporting limit. This includes the analysis of total reduced sulfur as hydrogen sulfide.

5.0 SAFETY

The toxicity or carcinogenicity of every reagent used in this method is not precisely known; however, the toxicity of each chemical compound should be treated as a potential health hazard. Exposure to these compounds should be reduced to the lowest possible level. Reference binders containing material safety data sheets (MSDS) are available to all personnel in the conference room. These shall be reviewed for the safe handling of the chemicals specified in this method.

5.1 Material Safety Data Sheets

The toxicity of each reagent used in this procedure may not be precisely defined. Material safety data sheets (MSDS) are available and should be reviewed as part of employee training. Care should be taken when handling standard material in neat or highly concentrated form.

5.2 Protective Clothing

Personal protective clothing (safety glasses, gloves and lab coat) are required when preparing standards, handling standards in neat form or performing maintenance on pressurized systems.

5.3 Pressurized Gases

The use of pressurized gases is required for this procedure. Care should be taken when moving cylinders. All gas cylinders must be secured to a wall or an immovable counter with a chain or a cylinder clamp at all times. Sources of flammable gasses (e.g., pressurized hydrogen) should be clearly labeled. Regulators must not be allowed to remain on size "D" cylinders when not in use.

5.4 Syringes

Care should be taken to avoid personal injury as a result of improper handling techniques.

6.0 SAMPLE COLLECTION, PRESERVATION AND STORAGE

Samples are collected in the field by the client and delivered to the laboratory for analysis. Because of the high reactivity of some of the sulfur compounds, Tedlar bags are the container of choice. Fused silica lined stainless steel sampling canisters have also been used for sampling these compounds.

This analysis does not require any sample preservation; however, Tedlar bags must be kept away from direct sunlight, as many compounds are photochemically reactive. Samples shall be analyzed within 24 hours from the verified time of sampling if possible; otherwise they should be analyzed within 24 hours from the time they were received at the laboratory. Passivated or lined vessels may allow for reliable sample analysis after 24 hours. In such cases, analysis is recommended within 7 days of collection. A majority of clients are unable to submit samples with sufficient time for the laboratory to perform the requested analysis (within 24 hours of sampling).

7.0 APPARATUS AND EQUIPMENT

7.1 Gas Chromatograph and Detector

The analysis is performed using a gas chromatograph, with a temperature-programmable oven with sub-ambient cooling capability, and necessary hardware to interface with a sulfur chemiluminescence detector. The GC shall have adjustable flow controllers and regulators for all compressed gases necessary for column carrier gas and operation of the detector.

Conditioning of the chromatographic column is required prior to use of the system. The column should be conditioned with a continuous flow of laboratory helium (UHP/ZERO 99.999% purity or better) and temperature programmed from 35 degrees Celsius to 250 degrees Celsius at a rate of five degrees per minute. The column should then be held at 250 degrees Celsius for at least four hours.

The SCD provides high sensitivity with linear and equimolar response over five orders of magnitude.

Laboratory Instrument ID	Instrument Model	Detector ID
GC 5	HP5890 II	SCD 1 (Sievers Model 355)
GC 13	Agilent 6890A	SCD 2 (Sievers Model 355)
GC 22	Agilent 7890	SCD 3 (Agilent model 355)

7.2 Data System

A data system able to collect data from the GC detector, integrate the peaks and be able to perform the appropriate quantitation calculations.

7.3 Tedlar Bags

Tedlar bags are used for collecting and diluting very concentrated samples.

7.4 Syringes

Gas tight syringes of the following volumes: 5mL, 2.5mL, 1mL, 500µL.

8.0 STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

All standards and reagents, must be prepared, handled and labeled in accordance with the *SOP for Handling Consumable Materials*. For purchased standards, a unique standard identification number, all concentrations, received date, expiration date, and balance gas, as well as analyst's initials must be identified on the label. Each prepared standard must include a unique standard identification number, the exact concentration of each analyte, expiration date, and balance gas, as well as analyst's initials (the date prepared shall be included in the laboratory standard identification number).

Certificates of analysis (CofA) must be maintained for all purchased standards and UHP gas cylinders. The CofA must include the information listed above and be turned in to the Quality Assurance Department for filing.

8.1 Reagents

8.1.1	Toluene	Reagent grade
8.1.2	Sylon CT	
8.1.3	Nitrogen	99.999%
8.1.4	Methanol	Reagent grade

8.2 Purchased Stock Standards (Primary and Secondary Sources)

Purchased stock standard cylinders (gas phase compounds) are used to prepare intermediate and working standards for the initial calibration (ICAL) and initial calibration verification/retention time/laboratory control sample (ICV/RT/LCS) standards. Two sources must be purchased (the second source must be from a difference manufacturer or lot and used for the ICV/RT/LCS standard) and each should be at a concentration of ~1000ppm and contain the following compounds in balance nitrogen:

Carbonyl Sulfide Hydrogen Sulfide Methyl Mercaptan

The compounds included in the primary stock, with the exception of methyl mercaptan and hydrogen sulfide may change as long as the compounds are included in the working second source standard (ICV/RT/LCS) if they are to be reported. These standards are purchased in gas cylinders and must be stored as described in Section 5.3 for a period of two years or as specified by the manufacturer.

8.3 Neat Standards

Neat standards are purchased at 95% to 99% purity. The compounds listed in Attachment D are routinely reported, and are used to prepare the retention time (RT) / initial calibration verification (ICV) / laboratory control sample (LCS) standard. The optional reporting compounds are also purchased in neat form.

Neat standards must be stored at -20°C to -10°C for a period of five years or as specified by the manufacturer. However, since acceptance criteria for reporting results only exist for those compounds included in the ICAL, these standards may be used past the expiration dates indicated. This is acceptable as long as no compound breakdown occurs which produces interference.

8.3.1 Intermediate Neat Cocktail A neat cocktail is prepared by preparing a equimolar solution. Calculate the number of microliters of each compound necessary for the desired final concentration of the working standard.

Example: For Carbon disulfide the desired concentration is 5ppm (since there are two sulfurs) instead of 10ppm for other compounds.

$$mg/m^3 = ppm * \frac{mw}{24.46}$$

$$mg/m^3 = 5ppm\frac{76.14}{24.46} = 15.564mg/m^3 = 15.564ug/L$$

where:

mw = molecular weight
24.46 = gas constant

Therefore, 15.564ug per liter is desired. Determine the actual amount required by using the following equation (density is 1266ug/uL).

$\frac{15.564ug/L}{1266ug/uL} = 0.01229uL/L$ or 0.0246uL spiked into a 2 liter glass bottle.

Perform these calculations for each compound. If the desired spike amount is too small then multiply by a constant like 1000 and that amount is to be spiked. Add up all of the spiked amounts (without any constant) to determine the exact volume to add to the working standard. If the amount is too small then a methanol standard should be prepared.

8.3.1.1 Neat Methanol Standard

If the spike amount is too small to adequately spike the static dilution bottle for the RT/ICV/LCS then an aliquot of the intermediate neat cocktail is spiked into methanol (for a 10X or 100X dilution).

8.4 Intermediate Standard (Primary and Secondary)

8.4.1 Primary (ICAL) Intermediate A stock standard (Section 8.2) is transferred to a Tedlar bag to generate an intermediate standard of 1000ppm. The intermediate standard is useable for up to 24 hours following preparation and shall be kept in a cool place and out of direct sunlight.

8.4.2 Secondary (ICV/RT/LCS) Intermediate Follow the same procedure specified above. This standard must be prepared from a second source (different manufacturer or lot from the primary stock).

8.5 Working/Initial Calibration Standard

Depending on the desired dynamic range of the initial calibration, dilutions are made from the intermediate standard (Section 8.4.1). Serial dilutions may also be performed in order to achieve the desired final standard(s) concentrations; however, this practice should be limited.

Source	Dilution	Container	Balance	Final Concentration
Intermediate (8.4.1)	100X (10mL/L)	Static Dilution Bottle	Nitrogen	10,000ppb
10,000ppb ICAL Working Standard	10,000X (1.0mL/100mls)	Static Dilution Bomb	Nitrogen	100ppb

The standard prepared in a static dilution bottle at 10,000ppb is good for a period of 2 months and the glass dilution bomb at 100ppb is good for a period of 24 hours.

Working standards may also be prepared in Tedlar bags and are stable for a maximum of 24 hours from time of preparation. All working standards must be stored in a cool place out of direct sunlight.

8.6 Continuing Calibration (CCV) Standard

The CCV is various injection volumes of a working standard described in Section 8.5. In addition, the CCV concentration should be at a level that was used in the initial calibration. The same expiration and storage information applies.

8.7 Initial Calibration Verification (ICV) / Laboratory Control Sample (LCS) Standard

The ICV and LCS standard may be used as the retention time standard; for preparation, expiration and storage requirements refer to Section 8.8.

8.8 Retention Time (RT) Standard

The retention time standard contains, but is not limited to, the compounds specified in Table 1 of Attachment D. Also, the standard may contain the compounds in Table 2 (Attachment D) if they are requested to be reported.

Source	Spike	Container	Balance	Final Concentration
Intermediate (8.4.2)	100X (10mL/L)	Glass Dilution Bottle	Nitrogen	Approx. 10000ppb(10ppm)
Neat Cocktail (8.3.1)	Spike determined from 8.3.1			
Neat Methanol Standard (8.3.1.1) (if utilized)	Spike amt. from 8.3.1 X the dilution of methanol standard.			

The retention time standard may be prepared in a static dilution bottle or inert canister from neat compounds (Section 8.3). This standard may also be prepared into a static dilution bottle or an inert canister from a standard cylinder supplied by an outside vendor.

The standard shall be stored in a box, away from light and to prevent breakage for a maximum period of two months. The expiration duration may prove to be shorter depending on standard performance.

8.9 Silanizing Solution

The solution may be prepared with 5mL dimethyldichlorosilane (DMDCS) in 100mL toluene. The solution shall be added to the standards logbook and the entry shall include the toluene and DMDCS manufacturer lot numbers.

A Sylon-CT solution may be obtained and used in place of the laboratory prepared solution. Regardless, the solution must be stored at -10°C to -20°C for a period of no longer than 2 years or as specified by the manufacturer.

9.0 PREVENTIVE MAINTENANCE

A maintenance log shall be kept documenting maintenance performed on each analytical system and the instrument maintenance log must be kept current. The serial numbers of each instrument shall be recorded in the front of the logbook. An entry shall be made in the appropriate log every time maintenance is performed. The extent of the maintenance is not important, however, it is important that a notation be included for each maintenance activity such as changing a column or injection port. The entry in the log must include:

(a) The date of maintenance
(b) Who did the maintenance
(c) Description of the maintenance
(d) Proof that the maintenance activity was successful

A notation of a successful continuing calibration or initial calibration shall serve as proof that the maintenance is complete and the instrument is in working order.

9.1 Gas Chromatograph

9.1.1 Column Due to the reaction between sulfur compounds and active sites, columns tend to perform better over time with the elimination of these active sites. However, if there is a noticeable decrease in performance and other maintenance options do not result in improvement, the column should be replaced. This is especially evident in calibration difficulties. Whenever GC maintenance is performed, care should be taken to minimize the introduction of air or oxygen into the column.

Clipping off a small portion of the head of the column may improve chromatographic performance. When cutting off any portion of the column, make sure the cut is straight and "clean" (uniform, without fragmentation) by using the proper column-cutting tool.

Poor performance can also be due to ineffective column ferrules, which should be replaced when a tight seal around the column is no longer possible. This can be detected with the use of a leak detector.

9.1.2 Injection Port Injection port maintenance includes changing the injection port liner and column ferrule as needed. Liners should be changed when recent sample analyses predict a problem with chromatographic performance. Injection port liners must be silanized prior to use. Silanize according to the procedure described in Section 11.2.

9.1.3 If in-line purifiers, scrubbers or traps are in place, these should be changed and maintained as recommended by the supplier.

9.1.4 Injector Septa For best results with air analysis, two septa should be used in the injector part. The septas should be changed periodically, whenever there is a noticeable change in peak definition.

9.1.5 Detectors Change reactor tube when needed, whenever there is a noticeable change in the background interference, peak definition, or sensitivity.

10.0 RESPONSIBILITIES

It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP and the *SOP for Documentation of Training* may perform analysis and interpretation of the results. The department supervisor/manager or designee performs final review and approval of the data.

11.0 PROCEDURE

Sufficient raw data records must be retained of the analysis (field samples, calibration standards and batch QC), instrument calibrations and method detection limit studies including analysis/calibration date, test method, instrument, sample identification, each analyte name, analyst's initials, concentration and response, and standards used for the analysis and calibrations as well as any manual integrations. Information entered and reported on the quantitation reports must be complete and accurate.

11.1 Cleaning Tedlar Bags, Static Dilution Bombs and Bottles

Tedlar bags frequently contain low levels of carbonyl sulfide and carbon disulfide. Bags are cleaned at the request of the client. At a minimum, all samples, standards and batch QC samples should be collected and/or prepared in Tedlar bags which have been treated similarly (i.e., if the sample bags have been cleaned, the MB, LCS, etc. bags should also be cleaned). Refer to Section 4.4 for additional information on Tedlar bag artifacts.

Tedlar Bags – are filled with nitrogen and evacuated several times. In the final cleaning step, partially fill the bags with nitrogen, heat for 20 minutes, and evacuate using a pump.

Static Dilution Bombs and Bottles – Heat to ~60°C for 30 minutes and purge for about 15 minutes (for bottles, ~30 seconds for bombs) from the liquid nitrogen dewer. Following the cleaning process the glassware should be silanized according to Section 11.2

11.2 Silanizing Procedure

- Rinse with silanizing solution (Section 8.9)
- Allow to air dry in hood
- Rinse with methanol
- Allow to air dry
- Place in oven at ~60°C for approximately 1 hour.

This procedure should be repeated anytime there is question as to whether or not a piece of equipment or apparatus is free of active sites, which will result in seeing lower concentrations of target analytes and greater concentrations of contamination.

11.3 Analytical Sequence and Data System Setup

11.3.1 Data System Load the appropriate temperature program on the GC with the EnviroQuant software. Load the appropriate analytical sequence. Enter the analytical sequence information in the table window, including sample/standard name, volume and method file. Load the appropriate quantitation analytical method (example, J:\GC13\methods\"appropriate ICAL"). Run the sequence and analyze the standards and samples in the appropriate order.

11.3.2 Analytical Sequence The number of samples in an analytical batch shall not exceed 20. Laboratory duplicates (LD), duplicate field samples, and sample dilutions are all considered samples. This analysis shall be run as a "closed" batch (beginning and ending with an acceptable CCV) and employs an external standard calibration procedure. Additionally refer to *SOP for Batches and Sequences.*

Analytical Sequence Guideline[1]

Sequence(w/ICAL)	***Sequence***	***Sequence (AQMD Compliant)[2]***
Calibration Stds.	CCV[8]	CCV[8]
ICV[3]	RTS/LCS[4]	RTS/LCS[4]
RTS/LCS[4]	MB[5]	MB[5]
MB[5]	Samples 1-10	Samples 1-10(in duplicate) [6]
Samples 1-10	CCV[8]	CCV[8]
CCV[8]	Samples 11-19	Samples 11-20(in duplicate) [6]
Samples 11-19	LD[7]	CCV[8]
LD[7]	CCV[8]	
CCV[8]		

[1]The analytical sequence is 20 field samples in addition to all of the appropriate QC. Batch QC samples may be analyzed anywhere in the analytical sequence; i.e., it is not necessary to analyze the batch QC samples in the exact order or position shown in this section.
[2]Any results that are to be submitted for SCAQMD compliance shall follow this guideline.
[3]The ICV is a second source standard used to verify the concentrations of the initial calibration standards; additionally, it may serve as the LCS for the batch.
[4]A LCS shall be analyzed at a rate of 1 in 20 or fewer samples. The retention time standard (RTS), in this case, may also be used as a laboratory control sample. The RTS/LCS should be analyzed following the continuing or initial calibration verification standards at the beginning of the sequence.
[5]The laboratory method blank must be analyzed at 1 in 20 or fewer samples.
[6]Compliance samples must be analyzed in duplicate.
[7]A laboratory duplicate must be analyzed at a frequency of 1 in 20 or fewer samples.
[8]Analysis must always end with the analysis of an acceptable CCV.

All steps in the analytical procedure must use the same reagents, equipment, apparatus, glassware, and solvents (for ICAL and daily standards, samples and QC).

11.4 GC Configuration

A sub-ambient GC oven temperature program separates all the peaks of interest. The temperature program ramps up to a high temperature (not to exceed the maximum temperature rating of the column in use) and holds there to allow all heavier sulfur containing compounds to elute within a 15 minute run and to prevent carry over to the next injection. The carrier gas for GC13 and GC22 is helium and GC5 uses hydrogen. The recommended settings and system parameters for analysis are as follows:

GC5 Instrument Control Parameters		
Sample Inlet: GC	Injection Source: Manual	Run Time: 16.6 min
Oven		
Initial Temperature: -30°C	Maximum Temperature: 270°C	
Initial Time: 0.0 min	Equilibration Time: 0.0 min	
Ramps		
Rate: 30°/min	Rate A: 10°/min	Rate B: 30°/min
Final Temp: 30°C	Final Temp: 100°C	Final Temp: 220°C
Final Time: 0.0 min	Final Time: 0.0 min	Final Time: 1.5 min
SCD 1		
Ozone Generator	**Reactor**	
O_2: 3 psi	H_2 – 50 kPa (approx.)	
Attenuation: 100	O_2 – 155 kPa (approx.)	
Pressure: 125 torr	Burner Temp.: 800°C	

GC13 Instrument Control Parameters		
Sample Inlet: GC	Injection Source: Manual	Run Time: 18.03 min
Oven		
Initial Temperature: -25°C	Maximum Temperature: 270°C	
Initial Time: 0.0 min	Equilibration Time: 0.0 min	
Ramps		
Rate: 30°/min	Rate A: 10°/min	Rate B: 30°/min
Final Temp: 30°C	Final Temp: 120°C	Final Temp: 240°C
Final Time: 0.0 min	Final Time: 0.0 min	Final Time: 1.0 min
SCD 2		
Ozone Generator	**Reactor**	
O_2: 3 psi	H_2 - 40 kPa (approx.)	
Attenuation: 100	O_2 - 8 mL/min (approx.)	
Pressure: 200 torr	Burner Temp: 800°C	

GC22 Instrument Control Parameters		
Sample Inlet: GC	Injection Source: Manual	Run Time: 16.00min
Oven		
Initial Temperature: -25°C	Maximum Temperature: 270°C	
Initial Time: 0.1 min	Equilibration Time: 0.0 min	
Ramps		
Rate: 30°/min	Rate A: 10°/min	Rate B: 25°/min
Final Temp: 50°C	Final Temp: 125°C	Final Temp: 235°C
Final Time: 0.0 min	Final Time: 0.0 min	Final Time: 1.5 min
SCD 3		
Ozone Generator	**Reactor**	
O_2: 3 psi	H_2 – 15 mL/min (approx.)	
Attenuation: 100	O_2 - 8 mL/min (approx.)	
Pressure: 200 torr	Burner Temp: 800°C	

INJECTORS (GC5, GC13, GC22)	**COLUMN** (GC5, GC13, GC22)
Mode: Packed column	Model #: Agilent DB-1, Restek RTX-1 or equivalent
Injector Temp: 150°C	Max. Temp: 270°C
Pressure: 20psi at -30°C oven temperature	Nominal Length: 60.0m
	Nominal Diameter: 0.53mm ID
	Film thickness: 5.0ul
	Carrier flow: 10mL/min

11.5 Retention Time Windows

Retention time windows must be established on each instrument initially, whenever there are changes to GC conditions, a new column is installed, or when a standard falls outside the previously generated windows. Analyte retention time windows are determined from the initial calibration and retention time standards.

1. Make sure that the system is operating reliably and that the system conditions have been optimized for the target analytes in the sample matrix to be analyzed.
2. Make four injections of all applicable standard mixes over a 72-hour period. Make the injections cover the entire 72-hour period or the end result could be windows that are too narrow.
3. Record the retention time for each single component analyte to three decimal places. Calculate the mean and standard deviation of the four absolute retention times for each single component analyte.
4. If the standard deviation of the retention times for the target compound is 0.000, then additional injections may be included or the use of a default standard deviation of 0.01 minutes.

5. The width of the retention time window for each analyte is defined as ±3 times the standard deviation of the mean absolute retention time established during the 72-hour period. If the default standard deviation of 0.01 (#4 above) is used, the width of the window will be 0.03 minutes.
6. Establish the center of the retention time window for each analyte by using the absolute retention time for each analyte from the retention time standard at the beginning of the analytical shift.
7. Retention time windows must be calculated for each analyte on each column and instrument.

11.6 Initial Calibration

Perform an initial calibration when the GC/SCD goes into service or when it is deemed necessary based on the performance of the CCV.

11.6.1 Initial Calibration Analysis Requirements

1. An initial calibration (ICAL) can be used as long as the initial calibration is not more than one year old, the continuing calibration verification standard (CCV) analysis at the beginning of and throughout the analytical sequence meets the analysis' criteria. Once a set of ICAL standards is analyzed and found to be acceptable, the previous ICAL can no longer be used to analyze new samples and it is to be archived. The curve fit selected at the time of the ICAL must be used for all analyses and cannot be changed. The only time an archived ICAL can be used thereafter is to review or re-evaluate sample(s) previously processed using that ICAL. *The practice of evaluating a CCV versus historical ICALs is not permitted.*

2. If a CCV analysis at the beginning of an analytical sequence fails to meet the analysis' criteria, a second CCV may be analyzed. If the second CCV meets the analysis' criteria, the analysis may continue. If the second CCV fails to meet the analysis' criteria, the analysis should be stopped, corrective action taken and documented.

   Initial calibration requirements
   a. A minimum of five concentrations
   b. The concentration of the lowest calibration standard must be at or below the MRL for each reportable analyte.
   c. The highest concentration, together with the lowest concentration, defines the calibration range.
   d. An instrument blank should be analyzed prior to beginning the analysis of the calibration standards and each analyte concentration in it should be <MRL.
   e. All the ICAL analyses must be completed within 48 hours.
   f. The initial calibration event must not be interrupted by maintenance.

g. Only one value per concentration is to be used.
h. Multiple analyses of a calibration standard and use of all the analyses in the ICAL or picking-and-choosing responses from one analysis or the other to use in the analyte's ICAL is not permitted. Once the ICAL has been used on a sample, it is not to be changed.
i. The ICAL must be verified by analysis of an ICV standard (i.e., a second-source standard) prior to the analysis of samples.
j. If 5 calibration standards are in the ICAL, one standard may be re-analyzed. If 6 to 10 calibration standards are in the ICAL, two calibration standards may be re-analyzed.
k. Point dropping policy:
   - Minimum of five consecutive concentrations is required.
   - Lowest concentration must be at or below the MRL and is not to be dropped unless the MRL is changed to the concentration of the remaining lowest standard.
   - Points may be dropped from the high end, but doing so lowers the calibration range.
   - Points must not be dropped from the "interior" of a curve unless there is an assignable cause* for doing so affects many (if not all) the analytes in the calibration standard. If a calibration standard is to be dropped from the interior of the curve, all the analytes in the calibration standard must be dropped from all the analytes' calibration curves.
   - If a point or a calibration standard is dropped, the reason must be documented.
   - A calibration standard may be re-analyzed if the first analysis of the standard has been dropped and the other requirements in this policy are met (e.g., still within 48 hours).

     * Assignable causes include
       - Standard preparation error
       - Instrument malfunction (e.g., it quits acquiring in the middle of the analysis)
       - Bad injection or purge

11.6.2 Initial Calibration Update Procedure

1. Open most recent method.
2. Save to new ICAL method ID. Date used in method ID is the date files were analyzed.
3. Clear all responses prior to update initiation and/or clear levels if different concentrations are to be used (Initial Calibration → Clear All Calibration Responses; Initial Calibration → Clear All Calibration Levels).
4. Quantitate standard.

5. Review all peaks for retention time, integration, etc.
6. Update responses for standard.
7. Repeat for all standards.
8. If necessary, load midpoint standard and update retention times.
9. Save method.
10. Verify Calibration Files listed on Response Factor Report are correct (Both Primary and Secondary Reviewer).
11. Verify responses of Page 3 of Edit Compounds are correct (Both Primary and Secondary Reviewer).
12. Verify file ID, acquisition time, quant time, update time, and last update information is correct on the Calibration Status Report (Both Primary and Secondary Reviewer).
13. Save Method. Confirm that no other copies of the method are open on other computer workstations.

Note: It is also acceptable to quantitate all standards and review all peaks before updating responses but steps 1-2 still must be completed initially. Step 3 also must be performed prior to beginning ICAL update.

11.6.3 Procedure Introduce each initial calibration concentration (Section 8.5) by direct injection using a gastight syringe. For a dynamic range of 5ppb to 5000ppb follow the injection guidelines stated in the table below. A different dynamic range may be desired; therefore, alternative injection volumes will be necessary.

Source	Injection, µL	Final ICAL Concentration
10,000ppb ICAL Working Standard (8.5)	50, 200, 500	500, 2000, 5000ppb
100ppb ICAL Working Standard (8.5)	50, 200, 500	5, 20, 50ppb

Follow the ICAL procedure requirements (number of points, point dropping, etc.). If necessary, a quadratic (force through zero) model may be used to calculate the ICAL. However, a relative standard deviation should be evaluated and used whenever possible.

11.6.4 Initial Calibration File

An ICAL file shall be created for each initial calibration performed per instrument and must include the following ICAL documents. The file shall remain in the laboratory and be filed by instrument and date.

- Injection log (optional)
- ICAL Review Checklist (completed)
- Blank analysis quantitation report
- Calibration status report (aka Calibration History)

- Relative Response Factor Report / Percent Relative Standard Deviation, if utilized
- Curve (quadratic) indicating "r^2", if utilized
- Quantitation report for each calibration standard (including manual integration documentation – before and after manual integrations)
- ICV quantitation report and evaluate continuing calibration report (aka Percent Difference Report-either automated or through manual calculations)

11.6.5 Initial Calibration Review

Analyst's calculation and assessment along with a peer review of all ICAL data and documentation is required. Sample results may only be reported if the ICAL is reviewed and found to be acceptable. The ICAL checklist in Attachment B must be properly completed to document the review and approval process and filed with the ICAL data file.

11.7 Initial Calibration Verification Standard

The ICV standard is analyzed following the initial calibration standards as a verification of the curve. Inject 200µL, of the retention time standard prepared in Section 8.8. A different aliquot may be required to yield an approximate concentration of 2000ppb depending on the actual concentration of the retention time standard.

11.8 Continuing Calibration Verification Standard

A continuing calibration standard must be analyzed initially, at least every ten samples (twenty sample injections for compliance analyses), as well as at the end of a sequence. The concentration of the CCV may be varied throughout the initial calibration range. Obtain the working standard (Section 8.5) or prepare another from the ICAL stock standard (Section 8.2).

11.9 Method Blank

Purge the syringe with nitrogen from the dewer and fill greater than 1mL, bring down to the desired injection volume (1mL) and inject.

11.10 Retention Time Standard / Laboratory Control Sample

The retention time standard may be used for both the ICV (Section 11.8) and LCS. Analyze the retention time standard (Section 8.8) at 2000ppb in order to establish the daily absolute retention times and apply the windows generated in Section 11.5 to identify analytes in field samples. In addition, determine if the percent recovery requirements for the LCS are met.

11.11 Laboratory Duplicate (Non-Compliance Analyses)

Obtain a second aliquot from the same sample container and perform the analysis of the laboratory duplicate. Duplicate analysis is conducted on a minimum of 1 in 20 samples per analytical sequence.

11.12 Sample Analysis

11.12.1 Guidelines Sample analysis may continue as long as the continuing calibration standard meets the criteria and the GC parameters remain unchanged within the batch requirements of Section 11.3.2. All samples must be analyzed under the same instrumental conditions as the calibration standards.

All *compliance* samples must be analyzed in duplicate with a relative percent difference of ≤5%.

11.12.2 Analytical Procedure Insert syringe through the Tedlar bag septum, pump the syringe and vent into a waste bag. Draw past the desired volume and slowly bring the barrel down to the mark. Remove the syringe tip and inject into the GC.

Identification of peaks: Retention time windows shall be generated in accordance with the procedure described in Section 11.5. Refer to Section 12.7 for specific identification requirements.

11.12.3 Sample Dilution

Samples require dilution if detector saturation occurs or if the quantified concentration is above the upper calibration range. Dilute the sample by either injecting a smaller volume or making a dilution in a Tedlar bag or glass dilution bomb. Make sure all of the appropriate dilutions are correctly recorded on the run log as well as the quantitation report.

Guidance in performing dilutions and exceptions to this requirement are given below.

- Use results of the original analysis to determine the approximate dilution factor required and get the largest analyte peak within the initial calibration range.
- The dilution factor chosen should keep the response of the analyte peak for a reported target compound in the upper half of the initial calibration range of the instrument. Additional compounds may be reported as long as they are within the calibration range or reported with the appropriate data qualifier.
- Analyses involving any dilutions that are to be reported require documentation with a dilution factor.

Tedlar bag dilution:

- Make a dilution by filling a Tedlar bag with nitrogen using a 1L gas-tight syringe.
- Calculate the volume of balance gas needed to obtain the required dilution.
- Remove the difference in the balance gas using a syringe
- Add the calculated sample amount using a gastight syringe.

Glass dilution bomb:

- Make a dilution by filling a bomb (125mL or 250mL) with nitrogen using a gas-tight syringe.
- Calculate the volume of balance gas needed to obtain the required dilution.
- Add the calculated sample amount using a gastight syringe.

11.13 Manual Integration

The manual integration for each peak shall be checked to ensure that they have been integrated properly. Assuming an incorrect integration the analyst shall conduct the manual integration in accordance with the *SOP for Manual Integration of Chromatographic Peaks* including all documentation and reviews associated with the process. The review shall include the analyst and reviewer both initialing and dating the manual integration as an indication of approval.

11.14 Method Detection and Quantitation Limits

The detection limit for this method is determined by following the guidelines in the *SOP for Performing Method Detection Limit Studies and Establishing Limits of Detection and Quantitation.* Detection limits must be determined each time there is a change in the test method, which affects how the test is performed, or when a change in instrumentation is such that it affects the sensitivity of the analysis. The MDL must be determined at a minimum annually for those compounds in the ICAL standard. All supporting data must be approved and retained.

11.15 Recertification of Second Source Standards

The second source stock standard used for the creation of the ICV and LCS/RT working standards may be recertified in house by one of the following methods or an equivalent procedure with approval of the QA PM.

11.15.1 Initial calibration analysis The stock second source standard is diluted to a level that resides inside the current calibration curve preferably about 10ppm (10000ppb). A 200ul aliquot is analyzed to represent 2000ppb. The concentration

is analyzed in triplicate and the results are averaged. See section 11.15.3 for interpretation of results.

11.15.2 10000ppb Concentration Analysis The stock primary source is used to make a working standard at 10000ppb. This working standard is analyzed at 2000ppb (200ul) three times and an average response factor is calculated using the equations is sections 13.7.3 and 13.7.4.

The stock second source standard is used to make a working standard at the same concentration as the primary source at 10000ppb. It is then analyzed in triplicate at 2000ppb(200ul) and quantified against the average response factor calculated from the primary triplicate injections. The results (of the calculated second source concentrations) are averaged. See section 11.15.3 for interpretation of results.

11.15.3 Recertification Criteria Compare the averaged results of the secondary source to the listed concentrations. If the values are within 5% then no change in concentration is necessary. If the concentration is within 5% to 10% then the new concentration is utilized for the recertified value. If the concentration is greater than 10% then the analyte cannot be recertified. All quantifiable analytes are assessed separately so that it is possible to have some analytes stay the same concentration and some change to a new value.

12.0 QA/QC REQUIREMENTS

This section contains technical acceptance criteria per the guidelines of the referenced test methods. Samples shall be reported only if all of the quality control measures are acceptable (to the extent possible). If quality control measures are found to be out of control, and the data must be reported, all samples associated with the out of control quality control measure shall be reported with the appropriate data qualifier(s).

12.1 Initial Calibration

Instruments must be calibrated initially and recalibrated whenever the laboratory takes corrective action (maintenance), which may change or affect the initial calibration criteria, or if the continuing calibration acceptance criteria have not been met.

All of the following information must be retained to permit reconstruction of the initial instrument calibration: calibration date, test method, instrument, analysis date, each analyte name, analyst's initials; concentration and response, response factor. There must be one concentration point at the reporting limit for each compound. If this is not the case then the reporting limit for each analyte must be raised to the lowest point on the curve.

The initial calibration acceptance criteria must be met prior to reporting any field samples or blank results. Refer to the following acceptance criteria for the initial calibration.

- All compounds in the low level standard must have at least a 3:1 signal to noise ratio.
- The RT for each target compound at each calibration level must be within the generated retention time window (using the mid-point as the absolute RT) and within 0.06 minutes of the mean RT for the compound.
- The calculated %RSD for the RF for each compound in the calibration standard must be less than or equal to 25%. If the RSD of the response factors is greater than 25% over the calibration range, then linearity through the origin cannot be assumed. If this is the case, the analyst may employ a quadratic or linear equation. This approach may also be employed based on past experience or a prior knowledge of the instrument response.
- All initial instrument calibrations must be verified with a standard obtained from a second manufacturer or lot.
- If utilizing a quadratic or linear regression curve, the coefficient of determination (r^2) must be ≥0.995 to be considered acceptable.

12.2 Initial Calibration Verification

The % difference must be +/-30% of the calculated concentration vs. the actual concentration of the ICV.

12.3 Continuing Calibration Verification

Sufficient raw data records must be retained to permit reconstruction of the CCV, e.g., test method, instrument, analysis date, each analyte name, concentration and response, and response factor. The CCV records must explicitly connect the continuing calibration data to the initial instrument calibration.

- The percent difference for each target analyte must be ±30% of the calculated concentration to proceed with further analyses.
- Each analyte must fall within the generated retention time window (using the RTS as the absolute RT) and the RT must be within 20 seconds (0.33 minutes) the mean RT from the initial calibration.

12.4 Retention Time Standard (Laboratory Control Sample)

The retention time for each compound in the ICAL must be within 0.33 minutes from the mean RT in the ICAL. For additional criteria, refer to Section 12.6.

12.5 Method Blank

The method blank result must not be greater than the method reporting limit (MRL) as long as the low standard of the initial calibration is at or below the set MRL.

12.6 Laboratory Control Sample

The percent recovery must fall within the laboratory generated limits listed in Attachment E.

12.7 Sample Analysis

12.7.1 Qualitative Analysis Positive qualitative identification of an analyte must include one of the following:

- RT within the generated retention time window of the retention time standard.
- The analyte must also fall within 0.1minutes of the RT in the daily RTS.

12.7.2 Quantitative Analysis One or both of the criteria for the qualitative analysis must be met in order for the analyte to be quantitated and reported without a data qualifier. Reporting an analyte (with a data qualifier) result which fails to meet the qualitative criteria is left to the discretion of the analyst.

12.8 Laboratory Duplicate

All of the requirements listed in Section 12.7 must also be met for the duplicate sample.

Non-compliance - The results of laboratory duplicates are acceptable when the relative percent difference (RPD) is within the laboratory generated limits in Attachment E.

Compliance – The RPD results must be less than or equal to 5%.

13.0 DATA REDUCTION AND REPORTING

The essential information to be associated with analysis, such as computer data files, run logs, etc. shall include: Sample ID code, date and time of analysis, instrument operating conditions/parameters (or reference to such data), analysis type, all manual calculations including dilutions and manual integrations, analyst's initials, sample preparation (pressure readings and balance gas), standard and reagent origin, receipt, preparation, and use; calibration criteria, frequency and acceptance criteria, data and statistical calculations, review, confirmation, interpretation, assessment and reporting conventions.

Results in units of ppbv obtained from an enviroquant data system are transferred to an excel spreadsheet and final results, including any dilution factors, are calculated on that spreadsheet.

Note: The spreadsheet used in the calculation must be validated and this validation shall be on file and available for review. In addition, no changes to this spreadsheet may be made without a new version designation and the generation of a new validation report.

13.1 Initial Calibration

The initial calibration curve must be saved with a specific method identification (i.e. two-letter identification followed by the date - mmddyy). No curve may be overwritten at any time to ensure a complete and accurate audit trail.

- Determine the mean retention time of each analyte spanning the initial calibration range using equation number 1.

Response Factor

- Tabulate the peak area along with standard concentration injected to determine the response factor (RF) using equation number 3 for each analyte at each concentration.
- Calculate the mean RF for each analyte per concentration spanning the initial calibration range using equation number 4.
- Calculate the percent relative standard deviation (%RSD) of the mean RF for each analyte over the calibration range for each concentration using equation numbers 5 and 6.

Linear Regression

If the %RSD is greater than 25% over the calibration range, the analyst may use a linear regression model.

- Calculate "r^2" or Coefficient of Determination utilizing equation number 7.

Quadratic Regression

If the %RSD is greater than 25% over the calibration range, the analyst may use a quadratic equation model.

13.2 Continuing Calibration Verification

Response Factor

- Calculate the response factor according to equation number 3.
- Calculate the concentration for each analyte using equation number 8.

Linear Regression

- Calculate the concentration for each analyte using equation number 9.

Quadratic Curve

- Calculate the concentration for each analyte using equation number 10.
- Calculate the % difference between the calculated concentration and the actual value using equation number 11.
- Determine the retention time difference for each analyte between the mean RT from the initial calibration and the RT from the CCV using equation number 2.

13.3 Initial Calibration Verification

Response Factor

- Calculate the response factor according to equation number 3.
- Calculate the concentration for each analyte using equation number 8.

Linear Regression

- Calculate the concentration for each analyte using equation number 9.

Quadratic Curve

- Calculate the concentration for each analyte using equation number 10.

Calculate the % difference between the calculated concentration and the actual value using equation number 11.

13.4 Retention Time Standard / Laboratory Control Sample

- Determine whether the retention time for each analyte falls within the generated retention time window.
- Calculate the percent recovery (%R) for all analytes using equation number 12.
- Determine the retention time difference for each analyte between the LCS and the RTS using equation number 2.

13.5 Laboratory Duplicate (Compliance and Non-Compliance)

- Determine the relative percent difference using equation number 13.

13.6 Sample Analysis

13.6.1 Qualitative Analysis

- Calculate the retention time difference of each identified analyte between the sample and the daily retention time standard using equation number 2.

13.6.2 Quantitative Analysis

Response Factor

- Calculate the concentration for each analyte by using equation number 8.
- Calculate all of the other analytes present in the sample using the average RF for methyl mercaptan in the initial calibration according to equation number 8.
- If the client requests "Total Reduced Sulfur as Hydrogen Sulfide", use equation number 8 with the total area for all peaks found and the average RF from H_2S.

Linear Regression

- Calculate the concentration for each analyte using equation number 9.

Quadratic Equation

- Calculate the concentration for each analyte by using equation number 10 (using Methyl mercaptan for those analytes not in the initial calibration standard).
- If the client requests "Total Reduced Sulfur as Hydrogen Sulfide", use equation number 10 with the total area for all peaks found and the sample using the regression equation from H_2S.

13.7 Calculations

13.7.1 Equation Number 1

Mean Retention Times ($\overline{RT}$)

$$\overline{RT} = \sum_{i=1}^{n} \frac{\overline{RT_i}}{n}$$

Where:

$\overline{RT}$	Mean retention time, seconds
RT_i	Retention time for the analyte in the standard, seconds
n	number of standards

13.7.2 Equation Number 2

Retention Time Difference (RTD)

$$\left| RT_C - RT_S \right|$$

where:

RT_C	Retention time of the target compound, seconds

RT_S Retention time of the compound in the standard, seconds

13.7.3 Equation Number 3

Response Factor (RF)

The response factor, for analyte *x* is given by:

$$RF = \frac{(P - P_o)}{C}$$

where:

P = peak area counts for the standard
P_o = calibration curve intercept; in most cases this is zero

C = concentration of analyte in the calibration standard
RF = response factor for analyte given as area counts

13.7.4 Equation Number 4

Average (or Mean) RF

$$\overline{RF} = \frac{\sum_{i=1}^{N} RF_i}{N}$$

where:

RF_i are the individual RFs from each concentration level in the initial calibration curve
N is the number of calibration concentration levels

13.7.5 Equation Number 5

Standard Deviation, SD

$$SD = \sqrt{\sum_{i=1}^{N} \frac{\left(RF_i - \overline{RF}\right)^2}{N-1}}$$

where:

RF_i are the individual RFs from each concentration level in the initial calibration curve

$\overline{RF}$ Average (or Mean) RF of all concentration levels in the initial calibration curve
N total number of calibration concentration levels

13.7.6 Equation Number 6

Percent Relative Standard Deviation, %RSD

$$\%\text{RSD} = \frac{SD}{\overline{RF}}(100)$$

where:

SD Standard Deviation calculated in equation number 3
$\overline{RF}$ Average or Mean RF

13.7.7 Equation Number 7

Correlation Coefficient (r) – Pearson Model

A correlation coefficient is a number between -1 and 1 which measures the degree to which two variables are linearly related. If there is perfect linear relationship with positive slope between the two variables, we have a correlation coefficient of 1; if there is positive correlation, whenever one variable has a high (low) value, so does the other. If there is a perfect linear relationship with negative slope between the two variables, we have a correlation coefficient of -1; if there is negative correlation, whenever one variable has a high (low) value, the other has a low (high) value. A correlation coefficient of 0 means that there is no linear relationship between the variables.

$$r = \frac{n(\sum XY) - (\sum X)(\sum Y)}{\sqrt{\left[n\sum X^2 - (\sum X)^2\right]\left[n\sum Y^2 - (\sum Y)^2\right]}}$$

Coefficient of Determination (r^2)

The multiple regression correlation coefficient, r^2, is a measure of the proportion of variability explained by, or due to the regression (linear relationship) in a sample of paired data. It is a number between zero and one and a value close to zero suggests a poor model. Square the r value obtained above, r^2 must be greater than or equal to 0.995.

13.7.8 Equation Number 8

Concentration (C) (%RSD Model)

$$C = \frac{Area}{\overline{RF}} \times \frac{D_{inj}}{A_{inj}}$$

or

Total Reduced Sulfur as H_2S

$$C = \frac{\sum Area}{\overline{RF}_{H_2S}} \times \frac{D_{inj}}{A_{inj}}$$

where:

Area	is the area obtained from the chromatogram
$\overline{RF}$	Average (or Mean) RF of all concentration levels in the initial calibration curve
D_{inj}	default injection volume (mL)
A_{inj}	actual injection volume (mL)

13.7.9 Equation Number 9

Concentration (C) (Linear Regression Model)

$$x_s = \frac{(A_s - b)}{a}$$

where:

x_s	Amount of sample
A_s	Area of analyte in sample
b	y-intercept
a	Slope or regression coefficient

13.7.10 Equation Number 10

Concentration (C) (Quadratic Model)

$$C = \frac{-b \pm \sqrt{b^2 - 4a(c - A_S)}}{2a}$$

where

C = Concentration
A_s = Area of the analyte
b = Intercept

a = Slope of the line

13.7.11 Equation Number 11

Percent Difference, %D,

$$\%D = \frac{C - C_{std}}{C_{std}}(100)$$

where, for any given analyte:

C = is the concentration being evaluated
C_{std} = is the concentration from the current calibration curve
C_{std} = actual concentration x injection volume

13.7.12 Equation Number 12

Percent Recovery (%R)

$$\%R = \frac{C}{S}x100$$

where

C = Concentration of the analyte recovered
S = Spiked amount

13.7.13 Equation Number 13

Relative Percent Difference (RPD)

$$\frac{|R_1 - R_2|}{\left(\frac{R_1 + R_2}{2}\right)}x100$$

where:

R_1 First measurement value
R_2 Second measurement value

13.7.14 Equation Number 14

Concentration w/Dilution Factor

Result : ppb x dilution factors x default inj. volume(mL)

injection volume(mL)

13.8 Data Review

The analyst must review data on a real time basis for all calibration and QC data. Any samples, QC samples or batch QC found to be unacceptable will require to be handled according to the guidelines described in this procedure. The QC data must be evaluated by analytical sequence following the data review checklist in Attachment C. The data shall be reviewed and the sample results calculated and assessed by one analyst and reviewed by a second qualified analyst. The data review checklist shall be used to document the reviews and once it has been completed, initialed and dated it is to be filed with each job file. In addition, the data review process shall be conducted in accordance with both the *SOP for Data Review and Reporting* and the *SOP for Laboratory Ethics and Data Integrity.*

Initial calibrations must be reviewed in the same manner as QC data with all ICAL documentation retained in a separate file organized by instrument and date. Refer to the initial calibration checklist in Attachment B for the review guideline. The ICAL file must contain all the pertinent information stated in Section 11.6.4.

13.9 Reporting

The results of each test shall be reported clearly, unambiguously and objectively, and shall include all the information necessary for the interpretation of the test results and all information required by this SOP and any additional information requested by the client. Refer to the *SOP for Data Review and Reporting* and Section 16.0 of this document for reporting information.

Results quantitated below the current method reporting limit may be reported with the appropriate flag upon request. However, due to artifacts, results for carbonyl sulfide and carbon disulfide below the MRL (for SKC Tedlar bags only) shall not be reported in this manner.

13.10 Sample Preparation and Analysis Observations / Case Narrative Summary Form

This form, which is included in the *SOP for Laboratory Storage, Analysis, and Tracking*, must be generated when there are specific sample composition information or analysis issues and/or observations. In addition, during the analysis, specific identification information or problems, interferences, calibration issues, flags, and additional/expanded explanation of flags should be added to the form. This form may be modified as long as the sections and basic concepts are reserved.

This form is necessary for documentation purposes. This form, among other information, will be reviewed when compiling the final report and case narrative. All information regarding the job shall remain in the file, in order that sufficient documentation is available to recreate the job from sample receipt through analysis, data reduction, and reporting.

14.0 METHOD PERFORMANCE

Method performance is evaluated by monitoring the recoveries and relative percent deviations from the laboratory control samples and their duplicates for a reference on precision and accuracy. In addition method detection limit studies shall be performed annually.

15.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

All waste generated by the performance of this document shall be disposed of in accordance with the *SOP for Waste Disposal*.

16.0 CORRECTIVE ACTIONS FOR OUT-OF-CONTROL DATA

All corrective actions shall follow the procedures outlined in the *SOP for Corrective Action*, where appropriate.

16.1 ICAL Results Do Not Meet Criteria

If the initial calibration technical acceptance criteria are not met, inspect the system for possible sources. It may be necessary to perform maintenance or perform other corrective actions to meet the initial calibration technical acceptance criteria. Refer to Section 11.6.1 for the initial calibration requirements as it includes information on dropping points. Also, check standards for a bad injection and re-analyze standard. If a bad injection is not evident, perform maintenance and attempt another ICAL (make notation in maintenance logbook regarding any steps taken).

16.2 ICV Results Do Not Meet Criteria

If the initial calibration verification does not meet the criteria, reanalyze. If the criterion still is not met, determine the cause and correct it. A recalibration will then have to be performed. If the recalibration does not meet the established criteria, new calibration standards must be made. A demonstration of an in-control system is required before proceeding with the analysis.

16.3 CCV Results Do Not Meet Criteria

If the criteria are not met, reanalyze the CCV standard. No more than two consecutive CCV standards should be analyzed before corrective action is initiated. If the variability is still greater than the criteria, either prepare a fresh CCV standard and reanalyze or a new calibration curve must be generated. Sample data associated with unacceptable calibration verification may be reported as qualified data under the following special conditions:

- When the acceptance criteria for the continuing calibration verification are exceeded high, i.e., high bias, and there are associated samples that are non-detects, then any non-detects may be reported. Otherwise the samples affected by the unacceptable calibration verification shall be reanalyzed after a new calibration curve has been established, evaluated and accepted.
- When the acceptance criteria for the CCV are exceeded low, i.e., low bias, those sample results may be reported if they exceed a known maximum regulatory limit. Otherwise the samples affected by the unacceptable calibration verification shall be reanalyzed after a new calibration curve has been established, evaluated and accepted.

16.4 Retention Time Standard (LCS) Results Do Not Meet Criteria

Reanalyze the standard, if the results still do not meet the criteria either prepare a new standard and calculate new retention time windows or recalculate the windows with the existing standard.

Note: No results may be reported for analytes associated with an out of control retention time standard.

16.5 Method Blank Results Do Not Meet Criteria

If the analyte results in the blank do not meet the acceptance criteria the source of the problem must be investigated and measures taken to eliminate the source. Determine whether the contamination is from the instrument or due to contamination in the nitrogen, syringe or other source. Regardless, appropriate corrective measures must be taken and documented. If the result in the blank has been determined to originate from the previous sample the blank may be reanalyzed. *If the results are the same, the blank along with all associated samples must be reported to the client with the appropriate qualifiers.*

16.6 Laboratory Control Sample Results Do Not Meet Criteria

If the LCS criteria are not met, determine whether the cause is instrumentation problems or the result of a poor injection. If necessary, perform maintenance and if the problem is with the injection re-analyzed the sample. If the LCS criteria are still not met, a new ICAL must be run or the data must be qualified.

16.7 Sample Analysis Results Do Not Meet Criteria

Results must not be reported without a data qualifier if they do not meet the acceptance criteria.

16.8 Laboratory Duplicate Results Do Not Meet Criteria

If the replicate results do not meet the technical acceptance criteria, determine if there was an injection problem. If this is the case, the sample should be re-analyzed. If the results are still unacceptable and there does not appear to be any matrix effects, interfering peaks, or instrument problems, the results for both injections shall be reported to the client. If there does not appear to be an injection problem, report both injections.

16.9 Corrective Action for Expired Sample Holding Time

Due to the extremely short hold time, samples may either arrive to the laboratory having already exceeded the 24-hour hold time or they are analyzed outside of the hold time. In cases where the client has previously been contacted and has expressed a desire to have samples processed regardless of the hold time situation, the client need not be contacted for future occurrences. Specific documentation for this allowance must be on file, which shall include the date and the initials of the person who spoke with the client.

A new customer or a customer which has not been previously contacted on this issue is to be notified that the sample's holding time was missed and the customer is to decide if the sample should be analyzed regardless of the holding time situation. The documentation of missed holding time and the client's decision to proceed must be included in the corresponding job file.

A statement dictating all holding time occurrences must accompany the sample results in the final report.

Note: Passivated or lined vessels may allow for reliable sample analysis after 24 hours. In such cases, analysis is recommended within 7 days of collection.

17.0 CONTINGENCIES FOR HANDLING OUT-OF-CONTROL OR UNACCEPTABLE DATA

17.1 Initial Calibration and Initial Calibration Verification

Sample data can not be associated with an out-of-control ICAL or ICV.

17.2 Continuing Calibration

An out-of-control methyl mercaptan shall not be used to quantitate other analytes. However, sample data associated with unacceptable calibration verification (for analytes other than methyl mercaptan) may be reported as qualified data under the following special conditions:

- When the acceptance criteria for the continuing calibration verification are exceeded high, i.e., high bias, and there are associated samples that are non-detects, then any non-detects may be reported. Otherwise the samples affected by the unacceptable

calibration verification shall be reanalyzed after a new calibration curve has been established, evaluated and accepted.

- When the acceptance criteria for the CCV are exceeded low, i.e., low bias, those sample results may be reported if they exceed a known maximum regulatory limit. Otherwise the samples affected by the unacceptable calibration verification shall be reanalyzed after a new calibration curve has been established, evaluated and accepted.

17.3 Retention Time Standard / Laboratory Control Sample

Results for an out of control LCS should be reported with the appropriate data qualifier.

17.4 Method Blank

All sample results associated with a "contaminated" method blank must be "flagged" in the report and/or discussed in the case narrative.

17.5 Laboratory Duplicate

A data qualifier must be included with an out of control LD result. When sample quality control results are out-of-control: Examine the sample results for matrix interferences and for carry-over. Re-analyze the samples and/or re-analyze the sample(s) at a lower aliquot. If the out-of-control results are due to matrix interferences, report the results with a matrix interference qualifier.

17.6 Field Sample(s)

If the retention time for the analyte in question is out of control; the RTS may be re-analyzed to evaluate the sample for that analyte. In addition, the RTS may be evaluated for an overall shift in retention times for each analyte. If this is the case and it is fully documented, the analyte(s) may be reported.

17.7 Hold Time

Holding time qualifiers must be included for those samples not received or analyzed within the required holding time. Refer to the note in Section 16.9 regarding information on hold times for canisters.

18.0 REFERENCES

18.1 South Coast Air Quality Management District Applied Science & Technology Division Laboratory Services Branch, SCAQMD Method 307-91, *Determination of Sulfur in a Gaseous Matrix,* March 1994.

18.2 ASTM D 5504-08, *Standard Test Method for Determination of Sulfur Compounds in Natural Gas and Gaseous Fuels by Gas Chromatography and Chemiluminescence.*
18.3 *SOP for Glassware Cleaning*, SOP Code ADM-Glass
18.4 *SOP for Laboratory Storage, Analysis, and Tracking*, SOP Code ADM-LabSAT
18.5 *SOP for Handling Consumable Materials*, SOP Code ADM-CONSUM
18.6 *SOP for Documentation of Training*, SOP Code ADM-TRANDOC
18.7 *SOP for Data Review and Reporting*, SOP Code ADM-DATA_REV
18.8 *SOP for Laboratory Ethics and Data Integrity*, SOP Code CE-GEN001
18.9 *SOP for Waste Disposal*, SOP Code DSP-Waste
18.10 *SOP for Batches and Sequences*, SOP Code ADM-BATCH_SEQ
18.11 *SOP for Performing Method Detection Limit Studies and Establishing Limits of Detection and Quantitation*, SOP Code ADM-MDL
18.12 *SOP for Manual Integration of Chromatographic Peaks*, SOP Code ADM-INT
18.13 *SOP for Corrective Action*, SOP Code ADM-CA

19.0 TRAINING PLAN

Training shall be conducted in accordance with the *SOP for Documentation of Training*. An initial demonstration of proficiency must be performed prior to independent analyses of samples. In addition, a continuing demonstration must be performed annually.

20.0 METHOD MODIFICATION

Method modifications include the following:

- Compound list: additional compounds are included and sulfur dioxide is omitted.
- The detectable concentration levels are in the low ppb range as opposed to the high ppb range.
- An ICAL is analyzed annually or when the CCV dictates (instead of monthly)
- Samples are not analyzed in duplicate
- CCV requirement is at 30% instead of 10%.

21.0 INSTRUMENT-SPECIFIC ADDENDUM

Not applicable

22.0 CHANGES FROM PREVIOUS REVISION

- Document readability improved with the removal of excessive section references.
- Section 3.9 Revised definition wording
- Section 5.0 Updated
- Section 6.0 Revised wording in 2nd paragraph
- Section 7.1 Information about column conditioning and Detector IDs added
- Section 8.0 Revised wording in 2nd paragraph
- Section 8.3.1.1 Added “intermediate” to neat cocktail

▪ Section 8.10	Removed obsolete section – standard recertification outlined in Section 11.15
▪ Section 11.0	Removed repetitive SOP reference
▪ Section 11.2	Revised paragraph
▪ Section 11.3.1	Revised paragraph
▪ Section 11.4	Revised to include carrier gas; New tables for Instrument Control Parameters; updated parameters
▪ Section 11.6	Removed redundant initial sentence
▪ Section 11.6.2	Added and renumber following sections
▪ Section 11.6.3	Revised wording in 2nd paragraph
▪ Section 12.0	Corrective Actions moved to Section 16.0
▪ Section 13.8	Updated second SOP title
▪ Section 13.9	QAM reference changed to SOP reference
▪ Section 13.10	Added – information previously in procedural section of SOP
▪ Section 16.0	Added reference to Corrective Action SOP and Corrective Actions added to section (previously in Section 12.0)
▪ Section 17.1	Rephrased
▪ Section 18.3→18.13	Added ADM SOPS referenced in document
▪ Section 20.0	Revised wording of third bullet
▪ Attachment A	Updated layout
▪ Attachment B	Updated layout
▪ Attachment C	Updated layout
▪ Attachment D	Updated MDL values and revised Note 1; Moved Isoamyl Mercaptan to Optional Sulfur Compounds Table
▪ Attachment E	Updated limits

23.0 ATTACHMENTS

Attachment A: Training Plan for Analysis of Sulfur Compounds in Air by Modified SCAQMD 307 & ASTM D5504

Attachment B: Sulfur in Air (Modified SCAQMD 307 & ASTM D 5504) Initial Calibration Checklist

Attachment C: Sulfur in Air per Modified SCAQMD Method 307 and ASTM D 5504 Data Review Checklist

Attachment D: Target Compounds and Corresponding Method Detection and Reporting Limits & Optional Compounds and Corresponding Method Detection and Reporting Limits

Attachment E: Laboratory Generated Control Limits

Attachment A

Training Plan for Analysis of Sulfur Compounds in Air by Modified SCAQMD 307 and ASTM D5504

Training Plan for Analysis of Reduced Sulfur Gases by GC/SCD

Trainee: _____ Trainer: _____ Date:_____

Instrument: ☐ GC5 ☐ GC13 ☐ GC22 ☐ _____

1. Read SOP — Trainer: ____ Trainee: ____ Date: _____

2. Read Methods: SCAQMD 307 ☐ and ASTM D5504 ☐ — Trainer: ____ Trainee: ____ Date: _____

3. Demonstrated understanding of the scientific basis of the analysis — Trainer: ____ Trainee: ____ Date: _____
   ☐Gas chromatography ☐ Sulfur Chemiluminescence Detector

4. Demonstrated familiarity with related SOPs — Trainer: ____ Trainee: ____ Date: _____
   SOP for Batches and Sequences; Rev. ____
   SOP for Making Entries into Logbooks and Onto Analytical Records; Rev. ____
   SOP for Manual Integration of Chromatographic Peaks; Rev. ____
   SOP for Significant Figures; Rev. ____
   SOP for Corrective Action. Rev. ____
   SOP for Performing Method Detection Limit Studies and Establishing Limits of Detection and Quantitation; Rev. ____
   SOP for Waste Disposal; Rev. ____

5. Observe performance of SOP — Trainer: ____ Trainee: ____ Date: _____
   ☐ Standard preparation
   ☐ Sample preparation (gas-phase dilutions)
   ☐ Analytical sequence setup
   ☐ Initial calibration and continuing calibration verification
   ☐ Sample analysis
   ☐ EnviroQuant introduction
   ☐ Data reduction and reporting

6. Perform SOP with supervision — Trainer: ____ Trainee: ____ Date: _____
   ☐ Standard preparation
   ☐ Sample preparation (gas-phase dilutions)
   ☐ Analytical sequence setup
   ☐ Initial calibration and continuing calibration verification
   ☐ Sample analysis
   ☐ EnviroQuant use
   ☐ Data reduction and reporting

7. Independent performance of the SOP — Trainer: ____ Trainee: ____ Date: _____
   ☐ Sample preparation (gas-phase dilutions)
   ☐ Standard preparation
   ☐ Analytical sequence setup
   ☐ Initial calibration and continuing calibration verification
   ☐ Sample analysis
   ☐ EnviroQuant proficiency
   ☐ Data reduction and reporting
   ☐ Initial demonstration of competency
      ☐ Four consecutive laboratory control samples; or

8. Instrument operation and maintenance — Trainer: ____ Trainee: ____ Date: _____
   - gas chromatograph and capillary column installation
   - detector (SCD) setup and maintenance - data system

Attachment B

Sulfur in Air (Modified SCAQMD 307 and ASTM D5504)
Initial Calibration Checklist

Sulfur in Air GC/SCD per SCAQMD 307M and ASTM D 5504

Initial Calibration Checklist

Instrument: ☐ GC5 ☐ GC13 ☐ GC22 ☐ _____
Analysis: ☐ SCAQMD 307M; ☐ASTM D 5504
ICAL Date: _____
Type of Curve: ☐ ***RSD*** ☐ ***Linear Regression*** ☐ ***Quadratic***

Analyst		***Reviewer***
☐	1. Is the required documentation in the ICAL file?	☐
☐	Sequence report	☐
☐	Blank analysis Quantitation Report	☐
☐	Calibration Status Report (aka Calibration History)	☐
☐	Calibration Curves (using linear regression or quadratic curve)	☐
☐	Response Factor Report (if utilized)	☐
☐	Quantitation Report for each calibration standard (including manual integration documentation – before and after printouts)	☐
☐	ICV Quantitation Report and Evaluate Continuing Calibration Report (aka Percent Diff. report)	☐
☐	2. Was the ICAL performed continuously low to high (i.e., not interrupted for maintenance or analysis)?	☐
☐	3. Was the ICAL, including any re-analysis, performed within a 48 hour period?	☐
☐	4. For each analyte, is the lowest standard's concentration at or below the MRL?	☐
☐	5. Does each analyte's ICAL include a minimum of 5 consecutive concentrations (one value per level) or 6 for a quadratic?	☐
☐	6. If a point is dropped, is information noted in the ICAL explaining the reason?	☐
	If a point was dropped from the interior was there a proper assignable cause?	
☐	7. For each analyte, are there no levels skipped?	☐
☐	8. Are all peak integrations including manual integrations (per SOP on manual integrations) acceptable? ***If so, initial and date the appropriate pages***.	☐

Quality Control

☐	9. Is the %RSD ≤25% for each compound?	☐
☐	10. For linear regression or quadratic calibration, is the COD ≥0.995?	☐
☐	11. For the ICV analysis, is the %D ±30%?	☐
☐	12. Is the RT for each target compound at each level within the generated retention time window (using the midpoint as the absolute RT) and within 0.06 minutes of the mean RT?	☐
☐	13. All the analytes in the MB are <MRL?	☐

COMMENTS: NA = Not applicable

Analyst: _____ Secondary Reviewer: _____
Date: _____ Date: _____

Attachment C

Sulfur in Air per Modified SCAQMD Method 307 and ASTM D5504
Data Review Checklist

Sulfur in Air per Modified SCAQMD Method 307 / ASTM D5504

Data Review Checklist

(Note exceptions in Comments Section and attach Nonconformity and Corrective Action Reports as appropriate)

Analysis Date: _____
Analyst: _____
CAS Project #: _____

Analysis: ☐ SCAQMD 307M; ☐ ASTM D 5504
Instrument: ☐ GC5 ☐ GC13 ☐ GC22 ☐ _____
QC level: _____
Due Date: _____

Analyst ***Reviewer***

Initial Calibration:

☐ 1. Is the referenced ICAL the most recent ICAL performed?..... ☐

Continuing Calibration:

☐ 2. Does each CCV in the sequence have a %D of ≤30%?..... ☐
☐ 3. Does the RT for each analyte for each CCV fall within the generated window, and within 20seconds of the mean RT from the ICAL?..... ☐

Batch QC (Compliant): *Complete only if applicable.*

☐ 4. Are the samples analyzed in duplicate with a RPD of ≤5%? ..... ☐
☐ 5. Is the % recovery for the *LCS* within the lab-generated windows for the analytes in the ICAL? ☐
☐ 6. All the analytes in the *MB* are <MRL? ..... ☐

Batch QC (Non-Compliant): *Complete only if applicable.*

☐ 7. Is a duplicate sample analyzed 1 per 20? ..... ☐
Is the RPD for the *laboratory duplicate* within the lab-generated limits? ..... ☐
☐ 8. Is the % recovery for the *LCS* within the lab-generated windows for the analytes in the ICAL? ☐
☐ 9. All the analytes in the *MB* are <MRL (as long as the low standard from the ICAL is ≤MRL)? .. ☐

Sample Data:

☐ 10. All target analyte responses are within calibration range?..... ☐
☐ 11. All peak integrations are acceptable? ..... ☐
☐ 12. All manual integrations are flagged and documented (before and after)? If so, initial and date. . ☐
☐ 13. Are all analyte peaks within the generated RT windows, using the RTD as the absolute RT and within 0.1 minutes of the RT in the daily RTS? ☐
☐ 14. First quantitation report initialed and dated by analyst?..... ☐
☐ 15. Are all of the QC, raw data, etc included?..... ☐

COMMENTS: NA = Not applicable

Analyst: _____ Secondary Reviewer: _____
Date: _____ Date: _____

Attachment D

Sulfur in Air per Modified SCAQMD Method 307 and ASTM D5504
Target & Optional Compounds with Corresponding Method Detection and Reporting Limits

GC13 and GC22 Sulfur Compounds Method Reporting Limits (ppb)

COMPOUND	MDL	MRL
Hydrogen Sulfide	1.8	5.0
Carbonyl Sulfide	2.0	5.0
Methyl Mercaptan	2.4	5.0
Ethyl Mercaptan	2.4	5.0
Dimethyl Sulfide	2.4	5.0
Carbon Disulfide	1.2	2.5
2-Propyl Mercaptan	2.4	5.0
t-Butyl Mercaptan	2.4	5.0
Propyl Mercaptan	2.4	5.0
Ethyl Methyl Sulfide	2.4	5.0
Thiophene	2.4	5.0
i-Butyl Mercaptan	2.4	5.0
Diethyl Sulfide	2.4	5.0
n-Butyl Mercaptan	2.4	5.0
Dimethyl Disulfide	1.2	2.5
3-Methyl Thiophene	2.4	5.0
Tetrahydrothiophene	2.4	5.0
2,5-Dimethyl Thiophene	2.4	5.0
2-Ethyl Thiophene	2.4	5.0
Diethyl Disulfide	1.2	2.5

Note 1: Method Detection Limits may be updated following the revision of this document; therefore, refer to the most recent Method Detection Limit studies.
Note 2: Method reporting limits may change with each new initial calibration. Therefore, check with the most recent documentation to verify values.

Optional Sulfur Compounds

COMPOUND
Ethylene Sulfide
Allyl Methyl Sulfide
2-Methyl Thiophene
2-Me-1-Butyl Mercaptan
Amyl Mercaptan
2-Me-Tetrahydrothiophene
Dipropyl Sulfide
Propylthiophene
Methyltrisulfide
Isoamyl Mercaptan

Attachment E

Laboratory Generated Control Limits

Laboratory Generated Control Limits

Analyte	LCS – LCL (%R)	LCS - UCL (%R)	LD (RPD)
Hydrogen sulfide	**51**	**141**	**34**
Carbonyl sulfide	**63**	**147**	**35**
Methyl mercaptan	**54**	**156**	**41**

Note: Limits are revised annually, check with the most recent documentation to verify limits. Accuracy and precision criteria for other compounds shall be the same as Methyl mercaptan.

B7. Method 1003: Phosphine

Method number:	1003
Target concentration:	0.3 ppm (0.42 mg/m^3, 12.3 nmol/L) TWA
OSHA PEL:	0.3 ppm (0.42 mg/m^3 12.3 nmol/L) TWA
ACGIH TLV:	0.3 ppm (0.42 mg/m^3 12.3 nmol/L) TWA 1 ppm (1.4 mg/m^3, 40.9 nmol/L) STEL
Procedure:	Samples are collected by drawing workplace air, with personal sampling pumps, through sampling cassettes containing a glass fiber filter and a mercuric chloride-treated polyester filter. Samples are digested with sulfuric acid and analyzed by ICP-AES.
Recommended sampling time and sampling rate:	240 min at 1.0 L/min (240 L) TWA 15 min at 2.0 L/min (30 L) STEL
Reliable quantitation limit:	32 ppb (45 µg/m^3)
Standard error of estimate at the target concentration:	5.52%
Status of method:	Evaluated method. This method has been subjected to the established evaluation procedures of the Methods Development Team. This method supercedes Method ID-180.

February 2000

Yihlin Chan
Phil Giles

Methods Development Team
Industrial Hygiene Chemistry Division
OSHA Salt Lake Technical Center
Salt Lake City UT 84115-1802

1. General Discussion

1.1 Background

1.1.1 History

With the application of phosphine in the manufacturing of semiconductors, the monitoring of workplace phosphine becomes more important than before. Phosphine has been analyzed by directly injecting sampled air onto a GC column. Both NPD[1] and FPD[2] have been used for detection. Wang et al. used gas sampling bags made of aluminum and polyester.[3]

The NIOSH method uses sampling tubes containing mercuric cyanide-coated silica gel. Samples are oxidized with acidic permanganate and analyzed by colorimetry.[4] OSHA Method ID-180 for sampling workplace phosphine uses carbon bead coated with potassium hydroxide.[5] The analysis is based on the oxidation of the collected phosphine with hydrogen peroxide, and the determination of the resulting phosphite and phosphate by ion chromatography, but the method suffers from low recoveries.

Greenfield et al. determined phosphine by passing air through a solution of mercuric chloride. Hydrogen chloride is liberated, causing a rise in conductance, proportional to the amount of phosphine absorbed.[6] They proposed the following reaction between phosphine and mercuric chloride:[7]

$$PH_3 + 3HgCl_2 \rightarrow P(HgCl)_3 + 3HCl$$

Matsumura and co-workers coated silica gel with mercuric chloride and used it to sample phosphine.[8] Samples are oxidized with acidic permanganate and analyzed by colorimetry. The sampling capacity was 3 L with 0.3 ppm phosphine sampled at 0.3 L/min. The lower limit of quantitation was 0.054 ppm. The sampling time of 10 minutes is not suitable for TWA sampling, and the colorimetric determinations are cumbersome.

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[1] Chughtai, M.; Pridham, P. N.; Cooke, M. Determination of phosphine by packed column gas chromatography with alkali flame ionisation detection. *Analytical Communications*, **1998**, 35, 109-111.

[2] Yang, G. and Dai, X. *Huanjing Baohu* (Beijin), **1994**, 59(12), 21-22.

[3] Wang, G.; Gao, Y.; Jiang, X.; Xiah, Y. Determination of phosphine in air by flame-photometric gas chromatography. *Weisheng Yanjiu*, **1994**, 23(2), 65-67; *Chem. Abstr.*, 121, 116336.

[4] Phosphine, Method 6002, NIOSH Manual of Analytical Methods, Fourth Edition. **1994**.

[5] Ku, J. Phosphine in Workplace Atmospheres. *OSHA Analytical Method*, ID-180, **1988,** modified, **1991**.

[6] Greenfield, S.; Moule, H. A.; Perry, R. The Conductimetric Determination of Microgram Amounts of Phosphine in Air. *Analyst*, **1966**, 9, 10-14.

[7] They proposed this reaction based on the amount of hydrogen chloride generated. The precise nature of the phosphorus containing entity is not certain.

[8] Matsumura, Y.; Ono-Ogasawara, M.; Furuse, M. Adsorption Sampling of Phosphine and Some Other Semiconductor Material Gases. *Appl. Occup. Environ. Hyg.*, **1993**, 8(4), 288-292. Determination of Phosphine by Adsorption Sampling with Modified Silica Gel and Colorimetry of Phosphine. *Industrial Health*, **1990**, 28, 175-184.

ICP-AES has been applied in the analysis of phosphorus. Hamalova and co-workers determined the phosphorus content of fertilizers using ICP-AES[9]. Ardis and Baker monitored the fertilizer plant effluents for phosphorus using ICP-AES[10]. Mortensen and co-workers collected phosphine in an impinger containing acidic permanganate solution and analyzed by ICP-AES.[11]

In the present method a mercuric chloride-treated polyester filter is used to capture phosphine and ICP-AES is used to analyze for the total phosphorus. A glass fiber filter is placed upstream to remove any phosphorus-containing particulate and aerosol.

1.1.2 Toxic effects (This section is for information only and should not be taken as the basis of OSHA policy.)

Phosphine is toxic by inhalation, but its effects are not completely understood. The chief effects are central nervous system depression and lung irritation. There may be pulmonary edema, dilation of the heart, and hyperemia of the visceral organs. Inhalation can cause coma and convulsions leading to death within 48 hours. However, most cases recover without after-effects. Chronic poisoning, characterized by anemia, bronchitis, gastrointestinal disturbances and visual, speech and motor disturbances, may result from continued exposure to very low concentrations.[12]

1.1.3 Workplace exposure

Two main uses for phosphine are in the preparation of semiconductors and as a fumigant.[13] Phosphine is commonly used in the electronics industry as an n-type dopant for silicon semiconductors, and to a lesser extent for the preparation of gallium-indium-phosphide devices. Phosphine generated *in situ* by the reaction of atmospheric moisture with pelletized calcium, aluminum, or magnesium phosphide is used as a fumigant in, for example, grain silos. Other uses of phosphine are as: polymerization initiator; condensation catalyst; chemical intermediate for phosphonium halides. Phosphine was not listed in either 1982 or 1972 NIOSH National Occupational Exposure Survey.[14] In the state of California for the period 1982-1992, there were reported 205 cases associated with exposure to phosphine/phosphides.[15]

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[9] Hamalova, M.; Hodslavska, J.; Janos, P. Determination of Phosphorus, Potassium, and Magnesium in fertilizers by Inductively Coupled Plasma-Atomic Emission Spectroscopy and Comparison with Other Techniques. *J. AOAC International*, **1997**, 80(6), 1151-1155.

[10] Aardis., J. D.; Baker, A. M. Monitoring of Fertilizer Plant Effluents for Phosphorus, Sulfur, and Metals Using Inductively Coupled Plasma Emission Spectrometry. *J. Assoc. Off. Anal. Chem.*, **1989**, 72(5), 857-859.

[11] Mortensen, G.; Pedersen, B.; Rietz, B. ICP-AES and colorimetry as analytical tools for the determination of phosphorus containing compounds, including phosphine. *Analytical Letters*, **1989**, 22(7), 1791-1806.

[12] *Sax's Dangerous Properties of Industrial Materials*, 8th edition; Lewis, R. J., Ed.; Van Nostrand Reinhold: New York, 1992. Vol. 3, p 2783.

[13] Rickelton, W. A. Phosphine and Its Derivatives, In *Kirk Othmer Encyclopedia of Chemical Technology*, 4th edition; Kroschwitz, J. I., Howe-Grant, M., Eds,; John Wiley & Sons: New York, 1996; Vol. 18, pp 656-668.

[14] *OSHA Regulated Hazardous Substances - Industrial Exposure and Control Technologies*, Government Institutes, Inc., Rockville, MD, 1990.

[15] *NIOSH Alert: Preventing Phosphine Poisoning and Explosions during Fumigation;* DHHS (NIOSH) Publication No. 99-126; U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health; Cincinnati, 1999, p 3.

1.1.4 Physical properties and descriptive information[16]

CAS number:	7803-51-2
synonyms:	hydrogen phosphide; phosphorus trihydride
molecular formula:	PH_3
molecular weight:	34.00
boiling point:	-87.7 °C
melting point:	-133.8 °Cvapor pressure:3.14×10^4 mmHg at 20 °C
odor:	of decaying fish; of garlic
auto-ignition temperature:	38 °C (pure). Ignites readily at room temperature when other hydrides of phosphorus are present as impurities. Combines violently with oxygen and the halogens.
solubility:	soluble in ethyl alcohol and ether; slightly soluble in water (26 mL in 100 mL at 17 °C).
OSHA IMIS number:	2080[17]

This method was evaluated in part according to the OSHA SLTC "EVALUATION GUIDELINES FOR AIR SAMPLING METHODS UTILIZING CHROMATOGRAPHIC ANALYSIS"[18] and in part according to the Inorganic Method Development Guidelines[19]. The Guidelines define analytical parameters, specify required laboratory tests, statistical calculations and acceptance criteria. The analyte air concentrations throughout this method are based on the recommended sampling and analytical parameters. Air concentrations listed in ppm are referenced to 25 °C and 101.3 kPa (760 mmHg).

1.2 Limit defining parameters

1.2.1 Detection limit of the analytical procedure

The detection limit of the analytical procedure is 0.088 µg/mL phosphorus. This is the concentration of phosphorus that will give a detector response that is significantly different from the response of a reagent blank. (Section 4.1)

1.2.2 Detection limit of the overall procedure

The detection limit of the overall procedure is 2.9 µg phosphorus per sample (10 ppb phosphine or 13 $\mu g/m^3$). This is the amount of phosphorus spiked on the sampler that will give detector response that is significantly different from the response of a sampler blank. (Sections 4.2)

1.2.3 Reliable quantitation limit

The reliable quantitation limit is 9.8 µg phosphorus per sample (32 ppb phosphine or 45 $\mu g/m^3$). This is the amount of phosphorus spiked on the sampler that will give detector response that is considered the lower limit for precise quantitative measurements. (Section 4.2)

[16] *Merck Index*, 10th Edition; Windholz, M. Ed.; Merck & Co.: Rahway, NJ, 1983.

[17] OSHA Salt Lake Technical Center, Chemical Sampling Information. http://www.osha-slc.gov/SLTC/ ChemSamp_data/ (accessed Dec 1999).

[18] Burright, D.; Chan, Y.; Eide, M.; Elskamp, C.; Hendricks, W.; Rose, M. C. *EVALUATION GUIDELINES FOR AIR SAMPLING METHODS UTILIZING CHROMATOGRAPHIC ANALYSIS*; OSHA Salt Lake Technical Center, U.S. Department of Labor: Salt Lake City, UT, 1999.

[19] OSHA Salt Lake Technical Center, Inorganic Methods Evaluation Protocol. http://www.osha-slc.gov/SLTC/analytical_methods/html-methods/imeprotocol//imeprotocol.htm (accessed Oct 1999).

1.2.4 Instrument calibration

The standard error of estimate is 0.041 µg/mL phosphorus over the range of 1.0 to 8.0 µg/mL. This range corresponds to 0.25 to 2 times the target concentration. (Section 4.3)

1.2.5 Precision

The precision of the overall procedure at the 95% confidence level for the ambient temperature 17-day storage test (at the target concentration) from mercuric chloride-treated filters is ±10.8%. This includes an additional 5% for sampling pump variability. (Section 4.4)

1.2.6 Recovery

The recovery of phosphine from samples used in a 17-day storage test remained above 94.8% when the samples were stored at ambient temperature. (Section 4.5)

1.2.7 Reproducibility

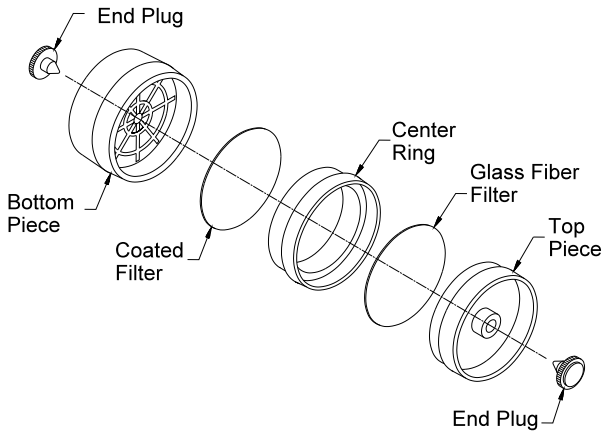
Six samples collected from a controlled test atmosphere were submitted for analysis by the OSHA Salt Lake Technical Center. The samples were analyzed according to a draft copy of this procedure after 38 days of storage at ambient temperature. No individual sample result deviated from its theoretical value by more than the precision reported in Section 1.2.5. (Section 4.6)

2. Sampling Procedure

All safety practices that apply to the work area being sampled should be followed. The sampling equipment should be attached to the worker in a manner that will not interfere with work performance or safety.

2.1 Apparatus

Samples are collected with 37-mm filter cassettes containing a glass fiber filter and a mercuric chloride-treated filter.[20]



[20] The treated filter was prepared by the following procedure. Thirty-seven-millimeter-diameter round filters were cut from a piece of polyester non-woven fabric (polyester non-woven, ultra firm, Style #9260, Handler Textile Co., Consumer Product Div., 24 Empire Blvd., Moonachie, NJ 07074). The filters were washed (sonication) twice with methanol, three times with 10% nitric acid, twice with de-ionized water, twice with methanol, and dried. A solution of 4.0 g of mercuric chloride and a small amount of methyl orange in 40.0 mL of 95:5 (v/v) methanol/glycerol was prepared. **Caution**: Mercuric chloride is a poison and slightly volatile at ordinary temperature. Forty cleaned filters were placed on a clean glass plate and, using an Eppendorf pipet with a plastic tip, 0.95 mL of the mercuric chloride solution was applied to each filter. The filters were allowed to dry in a hood for 30 min. The treated filters were stored in a sealed container in a refrigerator.

Samples are collected using a personal sampling pump calibrated, with the sampling device attached, to within ±5% of the recommended flow rate.

2.2 Reagents

None required.

2.3 Technique

Remove the two end plugs from the cassette.

Attach the cassette to the sampling pump. Position the sampling pump, cassette and tubing so they do not impede work performance or safety.

Draw the air to be sampled directly into the inlet of the cassette. For personal sampling, the air being sampled is not to be passed through any hose or tubing before entering the sampling cassette.

After sampling for the appropriate time, remove the cassette and replace the two end plugs. Seal each sample end-to-end with an OSHA-21 form.

Submit at least one blank sample with each set of samples. Handle the blank sampler in the same manner as the other samples except draw no air through it.

Record sample air volume (liters), sampling time (minutes) and sampling rate (L/min) for each sample, along with any potential interferences on the OSHA-91A form.

Submit the samples to the laboratory for analysis as soon as possible after sampling.

2.4 Sampler capacity (Section 4.7)

The sampling capacity was tested by sampling a dynamically generated test atmosphere of phosphine at 3.8 times the target concentration (46.8 nmol/L, 1.59 mg/m^3 or 1.34 ppm) at an absolute humidity of 16.3 milligrams of water per liter of air (74.9% relative humidity at 24 °C). The samples were collected at 1.0 L/min. The 5% breakthrough sampling time was determined to be 335 min. The 5% breakthrough was not reached in 6 hours when tested at two times the target concentration. When tested at 113.4 nmol/L (2.8 times the ACGIH STEL) and at a flow rate of 2.0 L/min, the 5% breakthrough sampling time was determined to be 40 min.

2.6 Recommended sampling time and sampling rate

Sample for up to 240 min at 1.0 L/min (240 L) to collect TWA (long-term) samples.

Sample for 15 min at 2.0 L/min (30 L) to collect short-term samples.

When short-term samples are collected, the air concentration equivalent to the reliable quantitation limit becomes larger. For example, the reliable quantitation limit is 0.36 mg/m^3 (10.5 nmol/L, 0.26 ppm) when 30 L are collected.

2.7 Interferences, sampling (Section 4.8)

The collection efficiency was above 94.6% when mercuric chloride-treated filters were used to sample a test atmosphere containing the target concentration of phosphine and having an absolute humidity of 4.6 milligrams of water per liter of air (22.2% relative humidity at 23.3 °C).

The collection efficiency was above 75.0% when mercuric chloride-treated filters were used to sample a test atmosphere containing 0.08 times the target concentration of phosphine and having an absolute humidity of 15.6 milligrams of water per liter of air (64.1% relative humidity at 26.0 °C).

The collection efficiency was above 99.6% when the samplers, whose front glass fiber filter had been spiked with 2.4 mg of ammonium phosphate dibasic,[21] were used to sample a test atmosphere containing one times the target concentration of phosphine and having an absolute humidity of 15.5 milligrams of water per liter of air (70.9% relative humidity at 24.1 °C). The average collection efficiency was 101.1% for the control samples.

The collection efficiency was above 96.7% when the samplers, whose front glass fiber filter had been spiked with 0.214 mg of DDVP,[21] were used to sample a test atmosphere containing one times the target concentration of phosphine and having an absolute humidity of 15.5 milligrams of water per liter of air (70.9% relative humidity at 24.1 °C). The average collection efficiency was 101.1% for the control samples.

3. Analytical Procedure

Adhere to the rules set down in your Chemical Hygiene Plan[22]. Avoid skin contact and inhalation of all chemicals. Review appropriate MSDSs before beginning work.

3.1 Equipment

3.1.1 Inductively coupled plasma-atomic emission spectrometer (ICP-AES). A Perkin-Elmer Optima 3000 DV, with its accessories including auto-sampler, peristaltic pumps, and mass flow controller, was used in this evaluation. The software controls the instrument and provides the analytical results.

3.1.2 Borosilicate glass Phillips beakers, 125-mL.

3.1.3 Borosilicate glass volumetric flasks, 25-mL,

3.1.4 Hot plate.

3.2 Reagents

3.2.1 Sulfuric acid, reagent grade. Sulfuric acid, 96.5%, purchased from JT Baker was used (Lot 15055).

3.2.2 Hydrogen peroxide, 30%. Hydrogen peroxide, 30%, was purchased from Mallinckrodt.

3.2.3 De-ionized water.

3.2.4 Phosphorus standard, 1000 µg/mL. Single element phosphorus standard, 1000 µg/mL, was purchased from SPEX Industries (Edison, NJ) and from CPI International (Santa Rosa, CA).

3.2.5. Nitric acid.

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[21] Ammonium phosphate and DDVP (2,2-dichlorovinyl dimethyl phosphate) were selected to represent residual fertilizers and semi-volatile organo-phosphorus pesticides that may possibly interfere with the sampling for phosphine during a grain fumigation operation. DDVP has a vapor pressure of 0.012 torr (1.6 Pa) at 20 °C. *(Documentation of the Threshold Limit Values and Biological Exposure Indices*, Sixth Edition; American Conference of Governmental Industrial Hygienists: Cincinnati, OH, 1991; p.446.)

[22] Occupational Exposure to Hazardous Chemicals in Laboratories. *Code of Federal Regulations*, Part 1910.1450, Title 29, 1998.

3.3 Standard preparation

3.3.1 Working standard, 10 µg/mL phosphorus (10 ppm P). Pipet 1.00 mL of 1000 µg/mL phosphorus stock solution into a 100-mL volumetric flask. Add about 50 mL of de-ionized water. Add 8 mL of concentrated sulfuric acid. Allow the solution to cool. Add de-ionized water to the mark.

3.3.2 Prepare a reagent blank in a 100-mL volumetric flask by adding 8 mL of sulfuric acid to about 50 mL of de-ionized water, allowing it to cool, and adding de-ionized water to the mark.

3.4 Sample preparation

Caution: Mercuric chloride is a "violent poison" and "slightly volatile at ordinary temperature".[23] It has a vapor pressure of 13 Pa (0.1 torr) at 100 °C.[24] Handle samples in a hood.

Clean the insides of the 125-mL Phillips beakers by refluxing 1:1 nitric acid using a hot plate in a ventilated hood. Carefully pour the used 1:1 nitric acid into an appropriate labeled container. Allow the beakers to cool, then rinse several times with de-ionized water. Using a forceps, place sample filters in separate labeled and washed Phillips beakers. Discard the glass fiber filter.

Add 2 mL of concentrated sulfuric acid to each beaker.

Heat the beakers on a hot plate for approximately 10 minutes. The solutions should become dark and then light brown.

Add a few drops of 30% hydrogen peroxide until each solution becomes colorless. Remove the beakers from the hot plate and allow to cool.

Quantitatively transfer the solutions into 25-mL volumetric flasks using de-ionized water. Add de-ionized water to the mark.

3.5 Analysis

Follow the standard operating procedure for ICP-AES. There are four available wavelengths for phosphorus determination: 178.221, 177.433, 213.616, and 214.918 nm. The wavelength of 178.221 nm was used in this evaluation. The results from the other three wavelengths are useful for confirmation. Calibrate with the 10 µg/mL phosphorus standard and the reagent blank. The instrument software allows for taking a specified number of readings and calculating the averages.

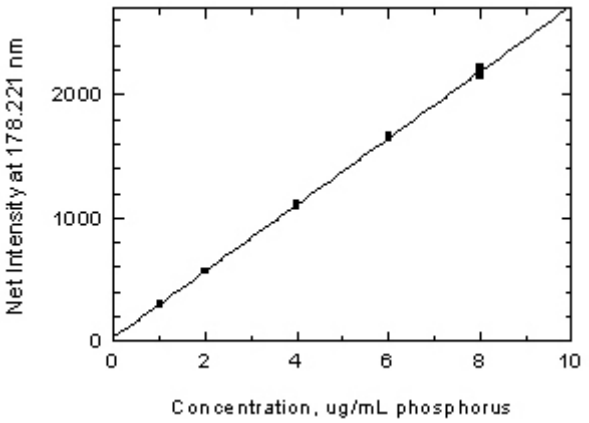

Figure 3.5. Calibration curve of phosphorus. (Y = 268.9X + 31.95).

[23] *Merck Index*, 10th Edition; Windholz, M. Ed.; Merck & Co.: Rahway, NJ, 1983, p 839.

[24] Nowak, M.; Singer, W. Mercury Compounds. In *Kirk-Othmer Encyclopedia of Chemical Technology*, 4th edition; Kroschwitz, J. I.; Howe-Grant, M., Eds; John Wiley & Sons: New York, NY, 1995; Volume 16, p 232.

ICP operating parameters:

number of replicates:	2
integration times:	minimum: 5.00 sec
	maximum: 20.00 sec
plasma flow:	15 L/min
auxiliary plasma flow:	0.5 L/min
nebulizer gas flow:	0.60 L/min
power:	1450 watts
viewing height:	15 mm
plasma view:	radial or axial

For the calibration curve presented in Figure 3.5, three readings were taken and the individual data points were plotted.

3.6 Interferences (analytical)

Copper and iron, when present in large amounts, may interfere with phosphorus detection at 213.616 and 214.914 nm. The ICP software allows for the correction of spectral interferences. Consult the instrument manual for inter-element corrections.

3.7 Calculations

The concentration of phosphorus for the sample is obtained from the appropriate calibration curve in terms of micrograms phosphorus per milliliter. This concentration is then corrected by subtracting the concentration of the blank. The air concentration is calculated using the following formulas.

$$C_M = \frac{(C_P)(V_d)(34.00)}{(V)(30.97)}$$

where C_M is concentration by weight (mg/m^3)
C_p is micrograms phosphorus per milliliter
V is liters of air sampled
V_d is the final volume (mL) to which the sample is diluted
34.00 is the molecular weight of phosphine (g/mol)
30.97 is the atomic weight of phosphorus (g/mol)

$$C_V = \frac{(24.46)(C_M)}{34.00}$$

where C_V is concentration by volume (ppm)
24.46 is molar volume at 25 °C (L/mol)
C_M is concentration by weight (mg/m^3)
34.00 is the molecular weight of phosphine (g/mol)

4. Backup Data

General background information about the determination of detection limits and precision of the overall procedure is found in the “Evaluation Guidelines for Air Sampling Methods Utilizing Chromatographic Analysis”[25]. The Guidelines define analytical parameters, specific laboratory tests, statistical calculations and acceptance criteria.

[25] Burright, D.; Chan, Y.; Eide, M.; Elskamp, C.; Hendricks, W.; Rose, M. C. *EVALUATION GUIDELINES FOR AIR SAMPLING METHODS UTILIZING CHROMATOGRAPHIC ANALYSIS*; OSHA Salt Lake Technical Center, U.S. Department of Labor: Salt Lake City, UT, 1999.

4.1 Detection limit of the analytical procedure (DLAP)

A 10 µg/mL phosphorus standard and a reagent blank were analyzed ten times and the data obtained were used to determine the DLAP according to the following formula.[26] At 178.221 nm, the 10 µg/mL standard gave an average intensity of 2717.8. The reagent blank gave an average intensity of 25.8 and a standard deviation of 7.87. DLAP was calculated to be 0.088 µg/mL phosphorus.

$$D_L = \frac{k(S_{dblk})(C_{std})}{(I_{std} - I_{blk})}$$

where D_L is detection limit
k is a constant, equals 3
S_{dblk} is the standard deviation of the reagent blank
C_{std} is the concentration of the standard
I_{std} is the intensity of the standard
I_{blk} is the intensity of the blank

4.2 Detection limit of the overall procedure (DLOP) and reliable quantitation limit (RQL)

The DLOP is measured as mass per sample and expressed as equivalent air concentrations, based on the recommended sampling parameters. Ten samplers were spiked with equal descending increments of phosphorus, such that the highest sampler loading was 20 µg/sample. This is the amount spiked on a sampler that would produce a peak approximately 10 times the response of a sample blank. These spiked samplers and the sample blank were analyzed with the recommended analytical parameters, and the data obtained used to calculate the required parameters (standard error of estimate and the slope) for the calculation of the DLOP. Values of 10.55 and 10.34 were obtained for the slope and standard error of estimate respectively. The DLOP was calculated to be 2.94 µg phosphorus per sample (9.67 ppb phosphine, 13.4 µg/m^3).

Table 4.2
Detection Limit of the Overall Procedure

mass per sample (µg phosphorus)	intensity at 178.221 nm
0	34.1
2	69.8
4	102.3
6	109.5
8	111.5
10	144.1
12	167.8
14	187.2
16	209.3
18	248.1
20	249.3

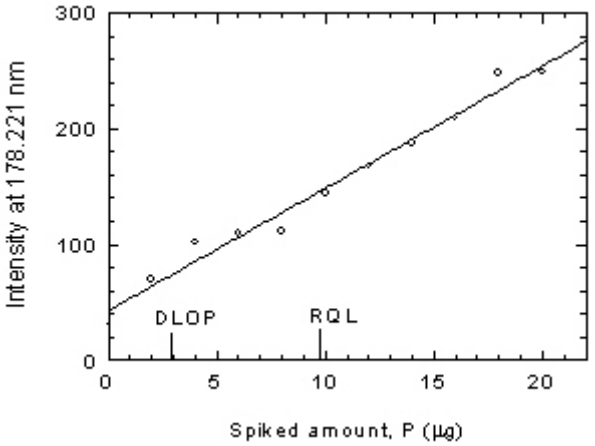

Figure 4.2. Plot of data to determine the DLOP/RQL. (Y = 10.55X + 42.91).

The RQL is considered the lower limit for precise quantitative measurements. It is determined from the regression line parameters obtained for the calculation of the DLOP, providing 75% to 125% of the analyte is recovered. The RQL is 9.80 µg phosphorus per sample (1.32 nmol/L, 32.2 ppb phosphine, 44.8 µg/m^3) Recovery at this concentration is 95.9%.

4.3 Instrument calibration

[26] OSHA Salt Lake Technical Center, Inorganic Methods Evaluation Protocol. http://www.osha-slc.gov/SLTC/analytical_methods/html-methods/imeprotocol//imeprotocol.htm (accessed Oct 1999).

The standard error of estimate was determined from the linear regression of data points from standards over a range that covers 0.25 to 2 times the target concentration. A calibration curve was constructed and shown in Section 3.5 from the three readings of five standards. A standard error of estimate of 15.38 and a slope of 268.7 mL/µg were obtained for the curve. The standard error of estimate of the calibration is calculated to be 0.0572 µg/mL phosphorus.

Table 4.3.
Instrument Calibration

standard concn (µg/mL P)	net intensity at 178.221 nm			average
1.00	303.5	305.4	298.4	302.4
2.00	570.6	567.9	568.7	569.0
4.00	1086.5	1104.3	1117.3	1102.7
6.00	1663.5	1646.6	1647.0	1652.4
8.00	2152.3	2173.6	2216.5	2180.8

4.4 Precision (overall procedure)

The precision at the 95% confidence level is obtained by multiplying the standard error of estimate by 1.96 (the z-statistic from the standard normal distribution at the 95% confidence level). In Section 4.5, 95% confidence intervals are drawn about their respective regression lines in the storage graph figures. The precision of the overall procedure of ±10.8% was obtained from the standard error of estimate of 5.52% in Figure 4.5.1.

4.5 Storage test

Storage samples for phosphine were prepared by collecting samples from a controlled test atmosphere using the recommended sampling conditions. The concentration of phosphine was at the target concentration with an absolute humidity of 14.8 milligrams of water per liter of air (86.3% at 19.9 °C).[27] Thirty-three storage samples were prepared. Three samples were analyzed on the day of generation. Fifteen of the samples were stored at reduced temperature (4 °C) and the other fifteen were stored in a closed drawer at ambient temperature (about 22 °C). At 3-4 day intervals three samples were selected from each of the two sets and analyzed.

Table 4.5
Storage Test for Phosphine

time (days)	ambient storage recovery (%)			refrigerated storage recovery (%)		
0	96.7	93.7	94.3	96.7	93.7	94.3
4	96.1	95.0	96.7	98.9	93.3	98.1
7	90.8	94.9	93.7	92.4	93.7	96.2
10	92.2	97.3	99.9	95.6	97.8	95.9
14	95.9	98.5	95.4	99.7	101.3	98.4
17	97.1	96.7	92.3	94.8	94.0	95.4

[27] The test atmosphere was generated by diluting a stream of certified 524.6 ppm phosphine in nitrogen (at a flow rate of 25.5 mL/min) with an air stream (at 38.38 L/min) from a Miller-Nelson humid air generator. The temperature was 19.9 °C and the barometric pressure was 86.8 kPa (651.3 mmHg). The phosphine concentration was calculated to be 0.348 ppm or 12.4 nmol/L.

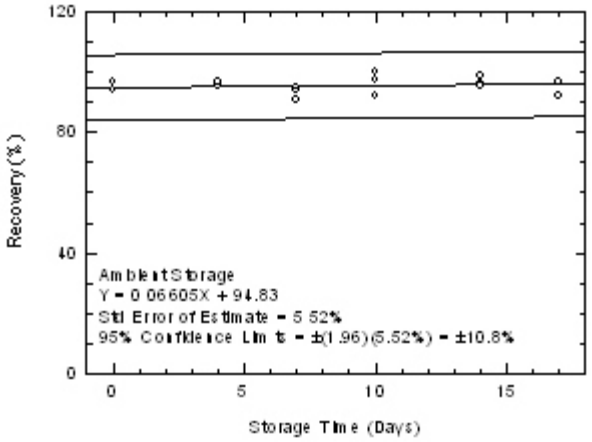

Figure 4.5.1. Ambient storage test for phosphine.

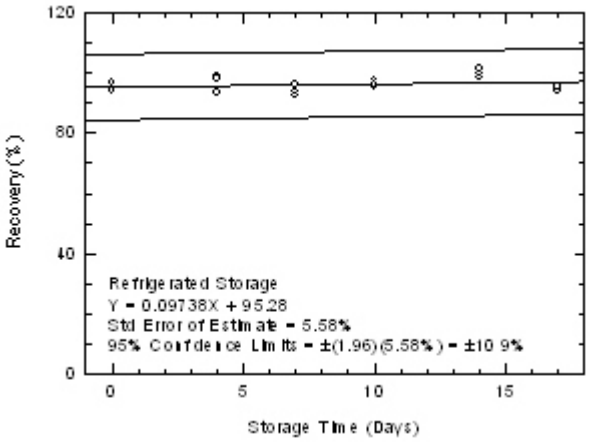

Figure 4.5.2. Refrigerated storage test for phosphine.

4.6 Reproducibility

Six samples were collected from a controlled test atmosphere similar to that which was used in the collection of the storage samples. The samples were submitted to the OSHA Salt Lake Technical Center for analysis. The samples were analyzed after being stored for 38 days at ambient temperature. No sample result for phosphine had a deviation greater than the precision of the overall procedure determined in Section 4.4.

Table 4.6
Reproducibility Data for Phosphine on Mercuric Chloride-Treated Filter

theoretical concentration (µg/L)	recovered amount (µg/mL P)	air volume (L)	concentration (µg/L)	recovery (%)	deviation (%)
0.4055	3.350	245.0	0.3753	92.6	-7.4
0.4055	3.339	242.9	0.3773	93.0	-7.0
0.4055	3.331	242.3	0.3773	93.0	-7.0
0.4055	3.247	241.7	0.3687	90.9	-9.1
0.4055	3.452	242.0	0.3915	96.5	-3.5
0.4055	3.403	245.0	0.3812	94.0	-6.0

4.7 Sampler capacity

The sampling capacity of the mercuric chloride-treated filter was tested by sampling from a dynamically generated test atmosphere of phosphine (46.8 nmol/L or 1.34 ppm at Salt Lake City) with an absolute humidity of 16.3 milligrams of water per liter of air (74.9% relative humidity at 24 °C) using two samplers connected in series. Three sets of samples were collected at 1.0 L/min. At 30-minutes intervals the downstream sampler was replaced with a fresh one. The 5% breakthrough was seen at 335 L of sampled air. No breakthrough was seen in 6 hours when the test was conducted at 26.2 nmol/L (0.738 ppm at Salt Lake City). The recommended sampling time is 4 h.

When tested at 113.4 nmol/L (2.8 times the ACGIH STEL TLV) and at a flow rate of 2.0 L/min, the 5% breakthrough time was found to be 40 min. The recommended short term sampling time and flow rate are 15 min and 2.0 L/min.

Table 4.7.1
Breakthrough of Phosphine with Mercuric Chloride-Treated Filter at 46.8 nmol/L and at 1 L/min

test no.	sampling time (min)	air vol (L)	downstream concn (nmol/L)	break-through (%)
1	0 -130	65.6	0.80	1.7
	130 - 206	169.5	0.61	1.3
	206 - 240	225.0	0.05	0.1
	240 - 270	257.3	0.01	0.0
	270 - 302	288.6	0.15	0.3
	302 - 330	318.8	1.89	4.0
	330 - 360	348.1	4.27	9.1
2	0 -130	65.0	0.74	1.6
	130 - 206	168.0	Outlier	-
	206 - 240	223.0	1.39	3.0
	240 - 270	255.0	0.61	1.3
	270 - 302	286.0	1.62	3.4
	302 - 330	316.0	1.35	2.9
	330 - 360	345.0	2.97	6.3
3	0 -130	64.6	0.54	1.1
	130 - 206	166.9	0.50	1.1
	206 - 240	221.5	1.46	3.1
	240 - 270	253.3	0.62	1.3
	270 - 302	284.1	0.62	1.3
	302 - 330	313.9	1.50	3.2
	330 - 360	342.7	1.85	4.0

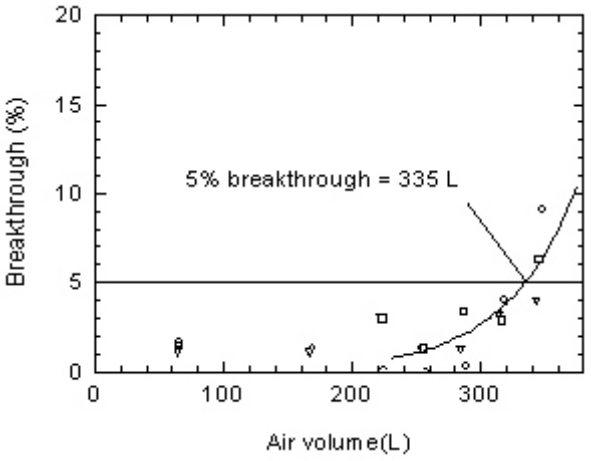

Figure 4.7.1. Five percent breakthrough air volume for phosphine at 46.8 nmol/L (3.8 times the target concentration) and a flow rate of 1.0 L/min.

Table 4.7.2
Breakthrough of Phosphine with Mercuric Chloride-Treated Filters
at 2 L/min and at 113.4 nmol/L (3.857 mg/m^3)

test no.	sampling time (min)	air vol (L)	downstream concn (nmol/L)	break-through (%)
1	0 - 33	32.8	4.1	3.6
	33 - 69	101.3	14.3	12.6
	69 - 99	166.8	22.1	19.5
	99 -133	230.4	27.6	24.3
2	0 - 33	33.0	0.3	0.2
	33 - 69	102.0	0.1	0.1
	69 - 99	168.0	12.8	11.3
	99 - 133	232.0	34.3	30.3
3	0 - 33	33.1	1.4	1.3
	33 - 69	102.2	3.3	2.9
	69 - 99	168.3	19.0	16.8
	99 -133	232.5	36.6	32.3

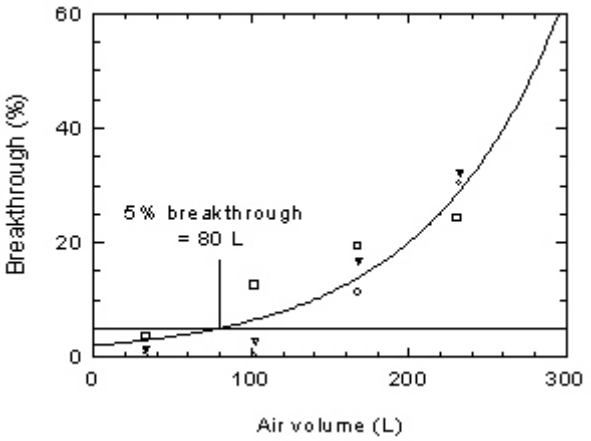

Figure 4.7.2. Five percent breakthrough air volume for phosphine at 113.4 nmol/L (2.8 times the ACGIH STEL TLV) and at a flow rate of 2.0 L/min.

4.8 Interferences (sampling)

Low humidity

The ability of the mercuric chloride-treated filter to collect phosphine from a relatively dry atmosphere was tested by sampling an atmosphere containing 12.2 nmol/L (one times the target concentration) of phosphine at an absolute humidity of 4.6 milligrams of water per liter of air (22.2% relative humidity at 23.3°C). Six samples were collected from the test atmosphere at 1.0 L/min for 240 minutes. All of the samples were immediately analyzed. The samples had collected 94.6%, 94.9%, 96.8%, 98.5%, 95.0%, and 103.3% of theoretical.

Low concentration

The ability of the mercuric chloride-treated filter to collect phosphine at low concentrations was tested by sampling an atmosphere containing 1.31 nmol/L (0.11 1times the target concentration) of phosphine at an absolute humidity of 14.0 milligrams of water per liter of air (63.8% relative humidity at 24.2 °C). Six samples were collected from the test atmosphere at 1.0 L/min for 240 min. The samples were immediately analyzed. The samples had collected 87.2%, 88.8%, 81.2%, 84.4%, 83.8%, and 82.4% of theoretical.

Interference

The ability of a mercuric chloride-treated filter coupled with the glass fiber filter to collect phosphine was tested when other potential interferences are present. Twelve samplers were used. The glass fiber filter of the three samplers were spiked with 100 µL of 24 mg/mL ammonium phosphate dibasic. The glass fiber filter of the next three samplers were spiked with 100 µL of 2.14 mg/mL DDVP in toluene. The remaining six samplers were used as controls. They were used to sample an atmosphere containing 11.9 nmol/L (0.97 times the target concentration) of phosphine at an absolute humidity of 15.5 milligrams of water per liter of air (70.9% relative humidity at 24.1°C) at 1.0 L/min for 240 minutes. All of the samples were immediately analyzed. The samplers with ammonium phosphate on the glass fiber filter had collected an average of 100.7% of theory. The three samplers with DDVP on the glass fiber filter had collected an average of 99.9% of theory. The six control samplers had collected an average of 101.1% of theory.

Table 4.8.1
Interference Tests for Phosphine

interference, amount placed on the front filter	recovery (%)			average recovery (%)
ammonium phosphate, dibasic, 2.4 mg	101.2	99.6	101.4	100.7
DDVP, 0.214 mg	102.7	96.7	100.2	99.9
control	93.3	105.7	103.1	101.1
	102.1	100.4	102.1	

Shelf life of the coated filter

The shelf life of the mercuric chloride-treated filter was tested by comparing the sampling recoveries of the 112-day-old filters with the 6-day-old ones. Three samplers from each set were used to sample an atmosphere containing 12.9 nmol/L (1.05 times the target concentration) of phosphine at an absolute humidity of 15.1 mg of water per liter of air (72.2% relative humidity at 23.3°C) at 1.0 L/min for 245 minutes. The average recovery from the 112-day-old filters was 83.5%. The average recovery from the 6-day-old filters was 93.4%. The filter is good for three months.

Table 4.8.2
Comparison of Old and New Filters

age of filters	recovery (%)			average (%)
112 days	80.2	92.3	77.9	83.5
6 days	94.3	94.5	91.3	93.4

B8: Field Screening with GasAlertMicro5

B8.a. SOP for Field Operating Procedures for the GasAlertMicro5® Portable Multi-Gas Detector

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Field Operating Procedures for the GasAlertMicro5® Portable Multi-Gas Detector

Rev. #: 1

Rev Date: July 24, 2012

Approval Signatures

Prepared by: _____ Date: _____
Kim Egler, Project Chemist

Reviewed by: _____ Date: _____
Chris Lutes, Principal Scientist

I. Scope and Application

Field screening with the BW Technologies GasAlertMicro5® Multi-Gas Detector can be used for simultaneous detection of one to five potential atmospheric hazards including oxygen, combustible gases and a range of toxic gases. It also is capable of data logging functions, and has audible, visual and vibrator alarms activate in the event of a low, high, TWA or STEL alarm conditions.

The GasAlertMicro5™ can also be configured with a variety of sensors, not all of which are needed for any one particular project. It is anticipated that this monitor may be used to analyze the following gases in the field: oxygen (by % volume or % LEL), hydrogen sulfide (ppm), phosphine (ppm), ammonia (ppm), hydrogen cyanide (ppm), and carbon dioxide (ppm). The GasAlertMicro5 can be used for surveys of potential sources, personal exposure monitoring or area surveys.

II. Personnel Qualifications

Personnel performing this method should be familiar with the basic principles of quantiative analytical chemistry (such as calibration) and familiar with the particular operation of the instrument to be used.

III. Equipment List

The following materials, as required, shall be available while performing field Screening with the GasAlertMicro5®:

- personal protective equipment (PPE), as required by the site Health and Safety Plan (HASP)
- GasAlertMicro5® and operating manual (available online, see references)
- extra batteries and battery charger
- Calibration hose and cap (standard with monitor)
- Screwdriver (standard with monitor)
- calibration canisters

IV. Cautions

Protect the combustible sensor from exposure to lead compounds, silicones, and chlorinated hydrocarbons. Although certain organic vapors (such as leaded gasoline and halogenated hydrocarbons) may temporarily inhibit sensor performance, in most cases, the sensor will recover after calibration.

BW recommends the combustible sensor be checked with a known concentration of calibration gas after any known exposure to catalyst contaminants/poisons (sulfur compounds, silicon vapors, halogenated compounds, etc).

Extended exposure of the GasAlertMicro 5/PID/IR detectors to certain concentrations of combustible gases and air may stress a detector element, which can seriously affect its performance. If an alarm occurs due to high concentration of combustible gases, recalibration should be performed, or if needed, the sensor replaced.

Electromagnetic interference (EMI) may cause incorrect operation under certain circumstances.

V. Health and Safety Considerations

The combustible sensor is factory calibrated to 50% LEL methane. If monitoring a different combustible gas in the % LEL range, calibrate the sensor using the appropriate gas. High off-scale % LEL or % v/v methane readings may indicate an explosive concentration.

Any rapid up-scaling reading followed by a declining or erratic reading may indicate a gas concentration beyond upper scale limit, which may be hazardous.

The GasAlertMicro5®detects elevated levels of oxygen, combustible gases, and hydrogen sulfide, all of which can be dangerous or life threatening. When using the GasAlertMicro5®, you must follow the instructions and warnings in the User Manual to assure proper and safe operation of the unit and to minimize the risk of personal injury. Be sure to maintain and periodically calibrate the GasAlertMicro5®as described in the manual and this SOP. Follow all procedures detailed in the site Health and Safety Plan (HASP) for monitoring at each location.

Since the GasAlertMicro5®cannot detect all of the chemicals that may be present at a sample location, a zero reading on either instrument does not necessarily signify the absence of air contaminants.

VI. Procedure (*Note these procedures were written particular to one specific instrument model, therefore please also refer to your owner's manual. However the general principles – such as always measuring both a zero and span gas at the beginning and end of the analytical day, or after suspected exposure to high concentrations of combustible gas can be applied to all comparable instruments.)*

GasAlertMicro5®Calibration

Operation, maintenance, and calibration shall be performed in accordance with the Manufacturer's instructions and entered into the project notebook. Prior to each day's sampling, a zero, span gas and an additional standard ("bump test") will be conducted to confirm linearity over the range of interest. The combustible sensor will be checked with a known concentration of calibration gas after any known exposure to catalyst contaminants/poisons (sulfur compounds, silicon vapors, halogenated compounds, etc). If an alarm occurs due to high concentration of combustible gases, recalibration will be performed, or if needed, the sensor replaced.

1. Don PPE, as required by the HASP.

2. Attach all the accessories before activating the detector (e.g., pump module, sampling probe, hose, etc.). To activate the detector, press the power button in a normal atmosphere (20.9% oxygen).

3. The instrument goes through a series of self test checks and shows screens for battery voltage, active gases, low alarm, high alarm, STEL and TWA, date and time, and sensor failures. It then goes into normal operation.

4. Verify that there is sufficient battery life for the intended monitoring period, and recharge if necessary.

Follow the calibration procedure as detailed in the User Manual starting on page 44. The relevant manual pages have been attached at the end of this SOP for convenience; the entire manual is also available online (see references). Details on the datalogger, maintenance, and troubleshooting can be found on pages 59, 68, and 73, respectively.

- Verify that the calibration gas you are using matches the span concentration value(s) in the detector.

- The detector should be allowed to stabilize for 1 minute, after activation, prior to calibration, or a bump test.

1. Perform the auto zero and oxygen sensor calibration. The display will notify you if the auto zero has failed for a sensor.

2. Perform the auto span. You can calibrate anywhere from one to all five sensors as desired. If the sensor(s) has spanned successfully, the audible alarm beeps three times. If there are more sensors to span, remove the existing calibration bottle, connect the next bottle, and continue with the auto span until call sensors have been calibrated successfully.

   If you apply gas to a sensor and the detector fails to span the sensor, repeat the calibration process using a new gas cylinder. If the sensor fails the span a second time, replace the sensor.

3. The detector displays “Saving calibration” to indicate that the calibration process is complete and then enters normal operation. To verify the calibration, “bump test” it using a gas cylinder other than the one used in calibration. The gas concentration should not exceed the sensor's detection range. Confirm that the display shows the expected concentration.

   If the display does not agree with the expected concentration within ±25% of the true value, then repeat the calibration procedure.

At the beginning and end of each daily use session of the instrument, introduce into the instrument after the calibration process is complete and the instrument “thinks” it is observing a sample three gasses:

- Zero gas
- Span gas of known concentrations of each analyte
- Midpoint gas of known concentrations of each analyte

Record the known concentration of the standard (usually written on the cylinder) and the observed concentration.

Compare the results of the span and midpoint gasses. If the result is outside of the range of 75-125% of the known true value, recalibrate the instrument and retest. If that is not successful immediately contact the project QA manager or project manager for advice.

VII. Waste Management

Do not dispose canisters of compressed gas, if there is still compressed gas in the canister. Return the canister to the manufacturer for proper disposal.

VIII. Data Recording and Management

GasAlertMic4ro5® monitors will be operated in a survey mode with time-stamped datalogging for those gasses amenable to field instrument monitoring (all analytes except for hydrofluoric acid; hydrogen, methane and acetylene will be monitored for LEL as described below). GPS data will also be recorded with a synchronized time stamp. Additional field information will be recorded in the field notebook at the time of measurement with notation of date, time, location, depth (if applicable), and item monitored. If a data memory is available, readings will be downloaded from the unit upon access to a computer with software to retrieve the data.

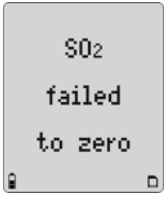
IX. Quality Assurance

After each use, the readout unit should be wiped down with a clean cloth or paper towel.

Verify that all calibration gases are within their expiration date.

X. References

BW Technologies. “GasAlertMicro 5 and GasAlertMicro 5 PID User Manual.” Available at http://fieldenvironmental.com/assets/files/Manuals/BW%20GasAlertMicro5%20Manual.pdf (accessed 7/24/12).



In auto span, if target gas is not detected or does not meet expected values, a message displays that the detector is exiting calibration mode. The detector retains the previous set values.

Applying Gas to the Sensors

The calibration cap and hose are shipped with the detector. Refer to Table 10 and Figure 3 for installation.

Note

The calibration cap can only be used during the calibration span process.

Table 10. Applying Gas to the Sensors

Item	Description
1	Detector and calibration cap
2	Calibration hose
3	Regulator and gas cylinder

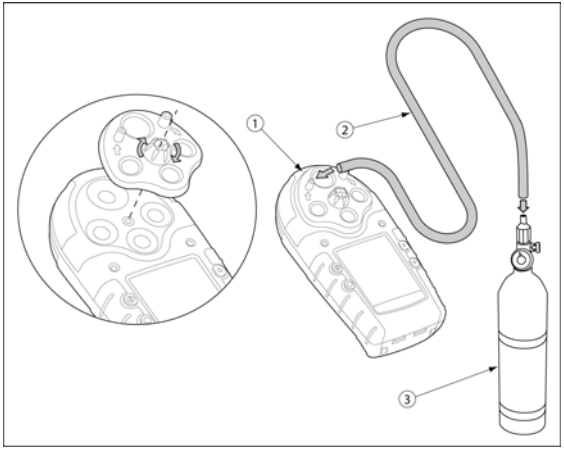


Figure 3. Applying Gas to the Sensors

Calibration Procedure

To calibrate the detector and set the alarm setpoints, perform the following procedures.

Note

To bypass a step during the calibration process (after auto zero), press ⓘ. Calibrate O_2 in clean air.

Start Calibration

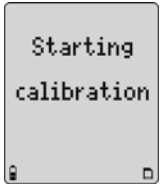
Note

Verify that the calibration gas being used matches the span concentration value(s) that are set for the detector. Refer to _Span Gas Value_.

Correction factors are not applied during calibration. Correction factors that were set prior to calibration are restored when the detector returns to normal operation.

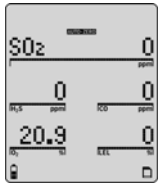
1. To enter calibration, in a clean atmosphere press and hold ◯ and ▼ simultaneously as the detector beeps, flashes, and vibrates to the corresponding countdown.

   The following screen displays to indicate that calibration mode has been entered.



Auto Zero and Oxygen (O_2) Sensor Calibration

2. AUTO-ZERO flashes while the detector automatically zeroes the toxic and combustible sensors, and calibrates the O_2 sensor.



Note

Do not apply calibration gas during this process, otherwise the auto zero step will fail.

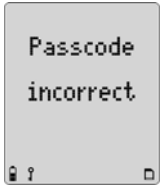
Passcode Protect Activated (Optional)

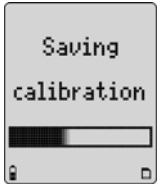
When auto zero is complete and if the passcode protect option is enabled, the detector prompts for the passcode.

The passcode must be entered to proceed. If required, refer to Passcode Protect in User Options menu.

3. Press ▲ or ▼ to scroll to the correct passcode. When it displays, press ◯ within 5 seconds to confirm. If the correct passcode is entered, the detector beeps twice and proceeds to the auto span.

Incorrect Passcode: If the passcode is incorrect or is not confirmed within 5 seconds by pressing ◯, the following screens display.

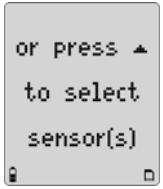


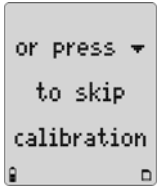


The detector saves the calibration and returns to normal operation.

Auto Span

After auto zero and the correct passcode is entered (if required), the following three screens display.





Note

Span sensors in the following order:

- *Exotics (NH_3, ClO_2, O_3, and Cl_2)*
- *Single gas*
- *Quad gas (H_2S, CO, LEL, and O_2)*
- *PID*

Apply Span Gas Now

Note

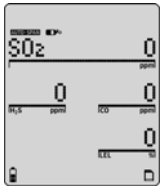
A generator must be used for O_3 and ClO_2 sensors.

- ***ClO_2:*** *BW recommends that a Tedlar bag be used as a buffer between the generator and the detector (while using the calibration cap) to regulate the flow rate to ensure accurate readings.*
- *Set the generator to 0.5 ppm at a flow rate of 0.5 l/min. (liter per minute).*
- *Allow the Tedlar bag to fill for several minutes before initiating calibration.*
- ***O_3:*** *Calibrate only using the calibration cap. Do not use a Tedlar bag.*

Depending upon the gas cylinder being used, one or all four sensors can be calibrated at one time.

4a. Attach the calibration cap and apply gas to the sensor(s) at a flow rate of 500 ml/min. (1000 ml/min. for NH_3 and Cl_2). Refer to Figure 3. Applying Gas to Sensors.

flashes as the detector initially detects the calibration gas.



After 30 seconds the detector beeps and stops flashing. AUTO-SPAN flashes while spanning the sensors until the detector has attained a sufficient level of the expected gas.

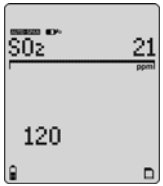
Refer to Table 11 for times required to span.

Table 11. Time Required to Span

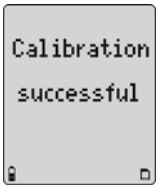
Gas Type	Time Required to Span
Most toxic gases	2 minutes
Exotic toxic gases	5 minutes
LEL (combustibles)	30 seconds
PID gases	2 minutes

Insufficient Level: If a sensor does not attain a sufficient level of expected gas, it is cleared from the LCD and is not spanned.

While the detector is spanning the sensor(s), a countdown of time remaining displays in the lower left of the screen.



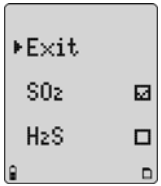
When the span is complete, the following screen displays.



Proceed to Successful Span step #5. If problems occur during the span, refer to Unsuccessful Span for possible solutions.

Select Sensor

4b. If ◯ is pressed to select **Sensor**, the following screen displays. The list of sensors will vary, depending upon the sensors that are installed.



Note

Only sensors that are selected are accepted for the current span.

Ensure that the checkbox is enabled for the sensor that is to be spanned.

Press ⓘ to exit. The **Apply span gas to calibrate** screen then displays. Refer to back to step #4a.

Skip Calibration

4c) If ⓘ is pressed, proceed to step #6.

Successful Span

If the sensor(s) has spanned successfully, the audible alarm beeps three times and the following screens display.

5. If there are more sensors to span, remove the existing calibration gas cylinder and connect the next cylinder.

   Press ▲ and apply gas to span the other sensor(s).

   Or

   Press ▼ to end the span and proceed to step #6 to set the calibration due dates.

If all of the sensors have successfully spanned, the following screen displays prior to continuing with the calibration process.

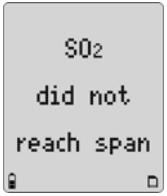
Unsuccessful Span

If the sensor(s) did not span successfully, refer to the following sections for possible solutions:

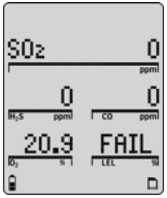
- Failed Span
- No Gas Detected
- Did Not Reach Target Span
- Large Span

Failed Span

If a sensor fails the span, the following error message displays.



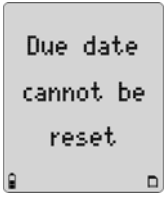
If the sensor is not recalibrated, the sensor displays as **FAIL** in normal operation the next time the detector is activated.



If all of the sensors fail the span, the following screen displays.

Press ⓘ to exit and then restart calibration in an atmosphere that is clear of the targeted gases. If the span fails a second time, restart the detector to test the sensors.

If all of the sensors fail the span, the due dates for calibration cannot be set.



If the detector fails to span the sensors, confirm the following:

- Ensure gas is being applied to the sensor.
- Ensure the sensors detect at least one-half of the expected gas concentration in the first 30 seconds.
- Ensure the gas concentration does not drop below one-half of the expected gas level during the span.

If the detector still fails to span the sensor(s), repeat the calibration using a new gas cylinder.

If the span is still unsuccessful, replace the sensor(s). Refer to Replacing a Sensor or Sensor Filter.

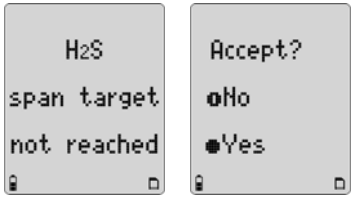
No Gas Detected

If the detector does not detect any gas within 30 seconds, the following screens display.

Press ▲ to reapply gas using another gas cylinder, or press ▼ to end the span and proceed to step #6.

Did Not Reach Target Span

If the span did not reach the target span as set in the user options menu (Span Gas Value) for the selected sensor, the detector displays the following screens.



Not reaching the target span can be the result of

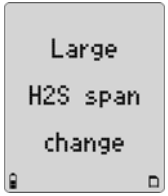
- a problem with the span gas,
- the gas cylinder being past the expiry date, or
- a problem with the sensor.

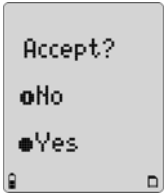
Accept Current Span: If the span gas, gas cylinder, and sensor appear to be correct, press ◯ to accept the current span.

Reject Current Span: Press ⓘ to reject. Verify the span gas and the detector settings, and then recalibrate the sensor.

Large Span

If the span adjustment is unusually large (more than 15%), the following screens display.





Ensure the calibration gas cylinder being used is correct and that the span concentration value(s) (refer to Span Gas Value) of the detector matches the value(s) of the gas cylinder.

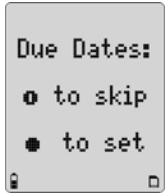
Adjustment Expected: If the calibration adjustment is expected, press ◯ to accept the span.

Adjustment Not Expected: If the calibration adjustment is not expected or the span gas value does not match the calibration gas cylinder, press ⓘ to reject the span and calibrate that sensor again.

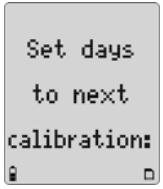
Setting the Calibration Due Date

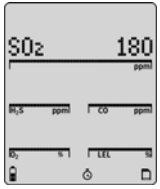
When the span is complete, the calibration due date can be set for each sensor that has spanned successfully.

The following screen displays.



6. Press ◯ to set the calibration due dates. The following screens display.





Note

*Unless a new due date value is entered, the detector automatically resets to the previously entered number of days (eg. **180**) for each sensor that has spanned successfully.*

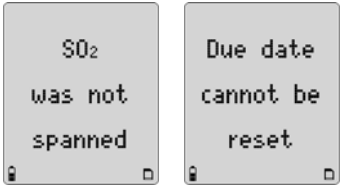
Or

Press ⓘ to bypass and proceed to step #9.

The calibration due dates are set in the following order:

- Toxic 1
- Toxic 2 (H_2S and CO)
- LEL
- O_2

If an attempt is made to change the due date of a unsuccessfully spanned sensor, the following screens display.



The detector then automatically proceeds to the next sensor.

7. To change the calibration due date (1-365 days), press ▼ or ▲ until the new value displays. Press ◯ within 5 seconds to confirm.

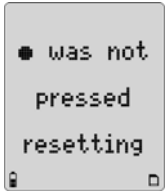
   Or

   Press ⓘ to bypass a sensor and proceed to the next sensor.

   The detector automatically proceeds to the next sensor to set the calibration due date.

Note

If a value is changed but ◯ is not pressed within 5 seconds to confirm, the following screen displays.



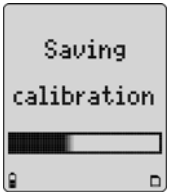
The previous value is automatically retained. The detector proceeds to the next sensor calibration due date.

8. Repeat step #7 to set the calibration due date for the remaining sensors.

9. Press ◯ to set the alarm setpoints and proceed to the following section Alarm Setpoints.

   Or

   Press ⓘ to bypass setting the alarm setpoints and proceed to Finish Calibration.



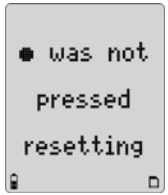
Alarm Setpoints

Factory alarm setpoints may vary by region. Refer to Resetting Gas Alarm Setpoints for an example. Alarms can be set to any value within the detection range of the selected sensor. Refer to Specifications.

Note

To disable an alarm setpoint, set it to **0** (zero).

When setting alarm setpoints, if the new setpoint is not confirmed within 5 seconds by pressing ◯, the following screen displays.



The previous setpoint is retained and the detector proceeds to the next setpoint.

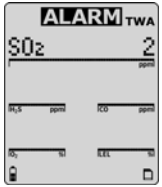
The setpoints are set in the following order:

- TWA (if applicable)
- STEL (if applicable)
- low
- high

To bypass a setpoint, press ◯ to save the current value and proceed to the next setpoint.

Setting the TWA Alarm Setpoint

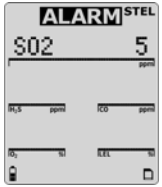
The current TWA alarm setpoint displays for the selected sensor (if applicable).



10. Press ▼ or ▲ to change the value for the TWA alarm setpoint. When the required value displays, press ◯ to confirm.

Setting the STEL Alarm Setpoint

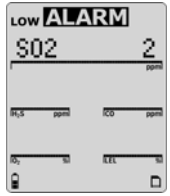
The current STEL alarm setpoint displays for the selected sensor (if applicable).



11. Press ▼ or ▲ to change the value for the STEL alarm setpoint. When the required value displays, press ◯ to confirm.

Setting the Low Alarm Setpoint

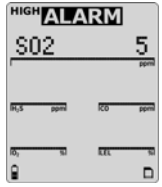
The current low alarm setpoint displays for the selected sensor.



12. Press ▼ or ▲ to change the value for the low alarm setpoint. When the required value displays, press ◯ to confirm.

Setting the High Alarm Setpoint

The current high alarm setpoint displays for the selected sensor.

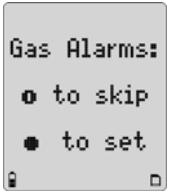


13. Press ▼ or ▲ to change the value for the high alarm setpoint. When the required value displays, press ◯ to confirm.

Setting the Remaining Alarm Setpoints

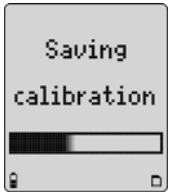
14. Repeat steps #10-13 to set alarm setpoints for the remaining sensors. The audible alarm beeps four times when the alarm setpoint function is complete.

    When the due dates have been set for all required sensors, the detector emits two quick beeps and then proceeds to the gas alarms setpoints screen.



Finish Calibration

The detector displays the following to indicate that the calibration process is complete.



The detector then returns to normal operation.

Verification

After calibration is complete and the detector is in normal operating mode, test it using a gas cylinder other than the one used for calibration. The gas concentration should not exceed the sensor's detection range. Confirm that the LCD displays the expected concentration values.

To ensure that the reading are accurate, apply the test gas for the same amount of time as was applied to the sensor when it was calibrated.

Example: SO_2 span time 2 minutes therefore, apply test gas for 2 minutes.

B8.b. GasAlertMicro 5 and GasAlertMicro 5 PID User Manual

GasAlertMicro 5 and GasAlertMicro 5 PID

O_2, CO, H_2S, PH_3, SO_2, Cl_2, NH_3, NO_2, HCN, ClO_2, O_3, VOC, and Combustibles

1, 2, 3, 4, and 5 Gas Detectors

User Manual

"INNOVATORS IN GAS DETECTION"

BW Technologies

Limited Warranty & Limitation of Liability

BW Technologies LP (BW) warrants this product to be free from defects in material and workmanship under normal use and service for a period of two years, beginning on the date of shipment to the buyer. This warranty extends only to the sale of new and unused products to the original buyer. BW's warranty obligation is limited, at BW's option, to refund of the purchase price, repair, or replacement of a defective product that is returned to a BW authorized service center within the warranty period. In no event shall BW's liability hereunder exceed the purchase price actually paid by the buyer for the Product.
This warranty does not include:

a) fuses, disposable batteries or the routine replacement of parts due to the normal wear and tear of the product arising from use;
b) any product which in BW's opinion, has been misused, altered, neglected or damaged by accident or abnormal conditions of operation, handling or use;
c) any damage or defects attributable to repair of the product by any person other than an authorized dealer, or the installation of unapproved parts on the product; or

The obligations set forth in this warranty are conditional on:

a) proper storage, installation, calibration, use, maintenance and compliance with the product manual instructions and any other applicable recommendations of BW;
b) the buyer promptly notifying BW of any defect and, if required, promptly making the product available for correction. No goods shall be returned to BW until receipt by the buyer of shipping instructions from BW; and
c) the right of BW to require that the buyer provide proof of purchase such as the original invoice, bill of sale or packing slip to establish that the product is within the warranty period.

THE BUYER AGREES THAT THIS WARRANTY IS THE BUYER'S SOLE AND EXCLUSIVE REMEDY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. BW SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES OR LOSSES, INCLUDING LOSS OF DATA, WHETHER ARISING FROM BREACH OF WARRANTY OR BASED ON CONTRACT, TORT OR RELIANCE OR ANY OTHER THEORY.
Since some countries or states do not allow limitation of the term of an implied warranty, or exclusion or limitation of incidental or consequential damages, the limitations and exclusions of this warranty may not apply to every buyer. If any provision of this warranty is held invalid or unenforceable by a court of competent jurisdiction, such holding will not affect the validity or enforceability of any other provision.

BW Technologies LP
2840 – 2nd Ave. SE
Calgary, AB
Canada T2A 7X9

BW America
3279 West Pioneer Parkway
Arlington, TX
USA 76013

BW Europe
101 Heyford Park,
Upper Heyford, Oxfordshire
United Kingdom OX25 5HA

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CAUTION: FOR SAFETY REASONS, THIS EQUIPMENT MUST BE OPERATED AND SERVICED BY QUALIFIED PERSONNEL ONLY. READ AND UNDERSTAND THE INSTRUCTION MANUAL COMPLETELY BEFORE OPERATING OR SERVICING.

GasAlertMicro 5 Multi-Gas Detector

Standard instrument is equipped with integral concussion-proof boot and internal vibrator alarm.

GasAlertMicro 5 with User Downloadable Datalogger

Provides full-time continuous datalogging while the instrument is operating. Data is saved on a convenient MultiMediaCard (MMC) or secure digital (SD) card and can be removed and downloaded by the user. Data is imported into standard office software (Microsoft® Excel, Access etc.). Wraparound memory ensures the most recent data is always saved. Datalogging instruments include the Fleet Manager software.

Accessing Test Results with Fleet Manager

To access and view test results using the Fleet Manager software application, refer to the Fleet Manager Support CD.

GasAlertMicro 5 and GasAlertMicro 5 PID

Introduction

⚠ Warning

To ensure your personal safety, read the Safety Information before using the detector.

The GasAlertMicro 5 gas detector ("the detector") warns of hazardous gas at levels above user-selectable alarm setpoints.

The detector is a personal safety device. It is your responsibility to respond properly to the alarm.

Table 1 lists the gases monitored.

Table 1. Gases Monitored

Gas Detected	Unit of Measure
Oxygen (O_2)	percent by volume (%)
Combustible gases field selectable for:	a) percent of lower explosive limit (% LEL) b) percent by volume methane 0-5.0% v/v
Carbon monoxide (CO)	parts per million (ppm)
Hydrogen sulfide (H_2S)	parts per million (ppm)
Phosphine (PH_3)	parts per million (ppm)
Sulfur dioxide (SO_2)	parts per million (ppm)
Chlorine (Cl_2)	parts per million (ppm)
Ammonia (NH_3)	parts per million (ppm)
Nitrogen dioxide (NO_2)	parts per million (ppm)
Hydrogen cyanide (HCN)	parts per million (ppm)
Chlorine dioxide (ClO_2)	parts per million (ppm)
Ozone (O_3)	parts per million (ppm)
Volatile organic compounds (VOC)	parts per million (ppm)

Contacting BW Technologies

To contact BW Technologies, call:

USA: 1-888-749-8878
Canada: 1-800-663-4164
Europe: +44 (0) 1869 233004
Other countries: +1-403-248-9226

Address correspondence to:

BW Technologies LP
2840 – 2 Avenue S.E.
Calgary, AB T2A 7X9
CANADA

Email us at: info@bwtnet.com

Or visit us on the World Wide Web: www.gasmonitors.com

ISO 9001

Safety Information - Read First

Use the detector only as specified in this manual, otherwise the protection provided by the detector may be impaired.

International symbols used on the detector and in this manual are explained in Table 2.

Read the **Warnings** and **Cautions** on the following pages before using the detector.

Note

This instrument contains batteries. Do not mix with the solid waste stream. Spent batteries should be disposed of by a qualified recycler or hazardous materials handler.

⚠ Cautions

⇒ ***Warning:*** **Substitution of components may impair Intrinsic Safety.**

⇒ ***Caution:*** **For safety reasons, this equipment must be operated and serviced by qualified personnel only. Read and understand the user manual completely before operating or servicing.**

⇒ **Do not use the detector if it is damaged. Before using the detector, inspect the case. Look for cracks and/or missing parts.**

⇒ **If the detector is damaged or parts are missing, contact BW Technologies immediately.**

⇒ **Use only sensor(s) that are specifically designed for the GasAlertMicro 5 and the GasAlertMicro5 PID models. Refer to Replacement Parts and Accessories.**

⇒ **Calibrate the detector before first-time use and then on a regular schedule, depending on use and sensor exposure to poisons and contaminants. BW recommends at least once every 180 days (6 months).**

⇒ **BW recommends to "bump test" the sensors before each day's use to confirm their ability and response to gas by exposing the detector to a gas concentration that exceeds the high alarm setpoints. Manually verify that the audible and visual alarms are activated. Calibrate if the readings are not within the specified limits.**

⇒ **It is recommended that the combustible sensor be checked with a known concentration of calibration gas after any known exposure to contaminants/poisons (sulfur compounds, silicon vapors, halogenated compounds, etc.).**

⇒ **The combustible sensor is factory calibrated to 50% LEL methane. If monitoring a different combustible gas in the % LEL range, calibrate the sensor using the appropriate gas. High off-scale % LEL or % v/v methane readings may indicate an explosive concentration.**

⇒ **Only the combustible gas detection portion of this instrument has been assessed for performance by CSA International.**

⚠ Cautions cont.

- ⇒ **Protect the combustible sensor from exposure to lead compounds, silicones, and chlorinated hydrocarbons. Although certain organic vapors (such as leaded gasoline and halogenated hydrocarbons) may temporarily inhibit sensor performance, in most cases, the sensor will recover after calibration.**
- ⇒ **Any rapid up-scaling reading followed by a declining or erratic reading may indicate a gas concentration beyond upper scale limit, which may be hazardous.**
- ⇒ **Use only recommended AA alkaline or NiMH batteries that are properly charged and installed in the detector case. Refer to Replacement Parts and Accessories.**
- ⇒ **Charge NiMH batteries using the recommended charger only. Do not use any other charger. Failure to adhere to this precaution can lead to fire and/or explosion.**
- ⇒ **Protect the PID sensor from exposure to silicone vapors.**
- ⇒ **The optional BW pump module (M5-PUMP) is certified for use with the GasAlertMicro 5 and the GasAlertMicro 5 PID only.**
- ⇒ **Read and adhere to all instructions and precautions in the literature provided with the charger. Failure to do so may result in fire, electric shock, personal injury, and/or property damage.**
- ⇒ **Extended exposure of the GasAlertMicro 5 and the GasAlertMicro 5 PID to certain concentrations of combustible gases and air may stress a detector element that can seriously affect its performance. If an alarm occurs due to high concentration of combustible gases recalibrate the sensor, or if required, replace the sensor.**
- ⇒ **Do not test the combustible sensor's response with a butane cigarette lighter; doing so will damage the sensor.**
- ⇒ **Do not expose the detector to electrical shock and/or severe continuous mechanical shock.**

⚠ Cautions cont.

⇒ **Do not attempt to disassemble, adjust, or service the detector unless instructions for that procedure are provided in the manual and/or that part is listed as a replacement part. Use only BW Technologies Replacement Parts and Accessories.**

⇒ **Do not immerse the detector in liquids.**

⇒ **The detector warranty will be voided if customer, personnel, or third parties damage the detector during repair attempts. Non-BW Technologies repair/service attempts void this warranty.**

Table 2. International Symbols

Symbol	Meaning
	Approved to both U.S. and Canadian Standards by the Canadian Standards Association
	European Explosives Protection
CE	Conforms to European Union Directives
BAM	BAM performance verification to European Performance Standards
ATEX	Conforms to European ATEX Directives
IECEx	International Electrotechnical Commission Scheme for Certification to Standards for Electrical Equipment for Explosive Atmospheres
	Type approved by ABS America for use aboard cargo vessels

Getting Started

The list below provides the standard items included with the detector. If the detector is damaged or parts are missing, contact the place of purchase immediately.

- Batteries: three replaceable alkaline cells or one rechargeable battery pack with the GasAlertMicro 5 Battery Charger
- Sensors: O_2, combustible (LEL), toxic, H_2S/CO (Twintox sensor), or PID
- Calibration hose and cap
- Screwdriver
- Quick reference guide
- Fleet Manager CD (if applicable)
- Manual and training CD

To order replacement parts, refer to Replacement Parts and Accessories.

The detector is shipped with sensors and alkaline batteries installed. To replace the sensors and batteries, refer to Maintenance.

To become oriented with the features and functions of the detector, refer to the following figures and tables:

- Figure 1 and Table 3 describes the detector's components
- Figure 2 and Table 4 describes the detector's Liquid Crystal Display (LCD) elements
- Table 5 describes the detector's pushbuttons

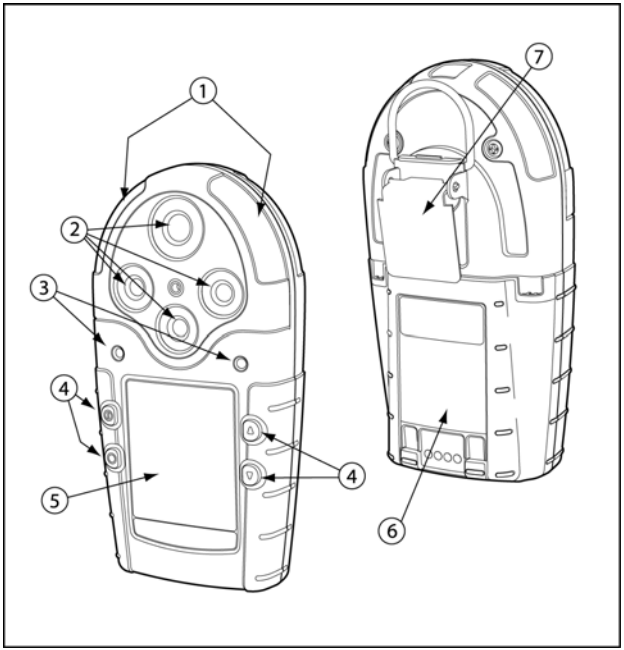


Figure 1. GasAlertMicro 5 and GasAlert Micro 5 PID Detector

Table 3. GasAlertMicro 5 and GasAlertMicro 5 PID Detector

Item	Description
1	Visual alarm bars (LED)
2	Sensors
3	Audible alarm
4	Pushbuttons
5	Liquid crystal display (LCD)
6	Battery pack
7	Alligator clip

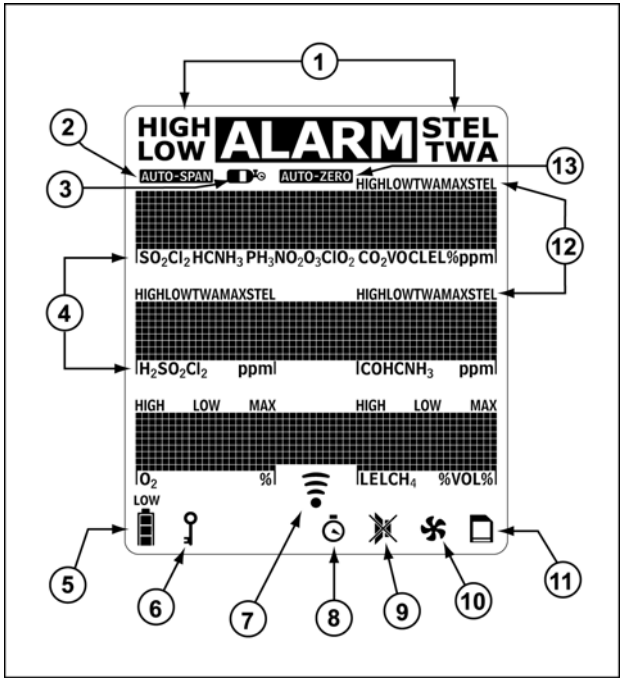


Figure 2. Display Elements

Table 4. Display Elements

Item	Description
1	Alarm condition
2	Automatically span sensor
3	Gas cylinder
4	Gas identifier bars
5	Battery life indicator
6	Pass code lock
7	Data transmission
8	Clock
9	Stealth mode
10	Optional pump indicator
11	Optional datalogger card indicator
12	Alarm condition (low, high, TWA, STEL, or multi-gas) or view TWA, STEL, and maximum (MAX) gas exposures
13	Automatically zero sensor

Note

If enabled, the backlight automatically activates for 8 seconds when there is an alarm condition and whenever there is insufficient light to view the LCD. Any pushbutton reactivates the backlight in low-light conditions.

Table 5. Pushbuttons

Pushbutton	Description
ⓘ	• To turn on the detector press ⓘ. • To turn off the detector, press and hold ⓘ until the countdown is complete (from normal operation only).
▲	• To increment the displayed value or scroll up, press ▲. • To enter the user options menu, press ▲ and ▼ simultaneously and hold until the countdown is complete. • To clear the TWA, STEL, and MAX gas exposure readings, press ◯ and ▲ simultaneously and hold until the countdown is complete. • To view the date and time, alarm setpoints (TWA, STEL, low, and high) of all sensors, and the LEL/PID correction factor (if applicable), press ▲.
▼	• To decrement the displayed value or scroll down, press ▼. • To initiate calibration and setting alarm setpoints, press ◯ and ▼ simultaneously and hold until the countdown is complete.
◯	• To view the TWA, STEL, and MAX hold readings, press ◯. • To acknowledge latched alarms press ◯.

Activating the Detector

Attach all of the accessories prior to activating the detector (e.g., pump module, sampling probe, hose, etc.). For illustrations and procedures, refer to Attaching the Accessories.

To activate the detector, press ⓘ in a normal atmosphere (20.9% oxygen).

Self-Test

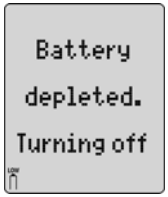
Once the detector is activated, it performs several self-tests. Confirm the following tests occur.

Note

If an error message displays during the self-test, refer to Troubleshooting.

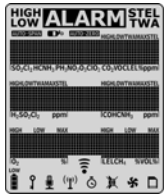
The detector performs a battery test during start-up.

If the battery has insufficient power to operate, the following screen displays before deactivating.



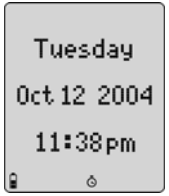
Replace the batteries and reactivate the detector.

1. All of the LCD elements display simultaneously as the detector beeps, flashes, vibrates, and briefly activates the backlight.



2. The version and serial number of the detector displays.

3. The date and time displays.



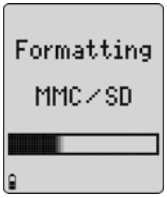
Datalogging Unit (Optional)

4. If the detector is a datalogging unit, it determines if
   - a MultiMediaCard (MMC) or secure digital (SD) card is inserted,
   - the detector can communicate with the card,
   - the detector supports the size of the card, and
   - the card requires formatting.

Note

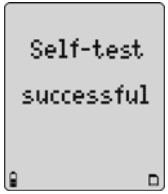
If there is a problem with the MMC/SD, ***Datalogger disabled*** *displays. The detector then automatically continues with the self-test.*

If the card requires formatting, the following screen displays as the card is automatically formatted.

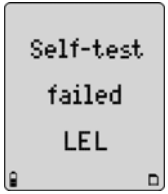


5. The detector then runs a self-test to verify the sensors and power supply.

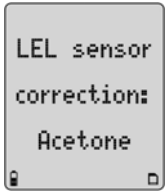
Self-test Successful: If successful, the following screen displays.

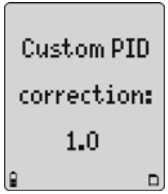


Self-test Unsuccessful: If a sensor fails the self-test, a warning displays indicating which sensor(s) has failed.



6. If correction factors are set in the user options, the LEL or PID (custom) correction factors display.

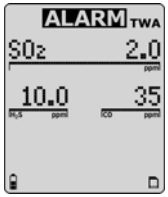


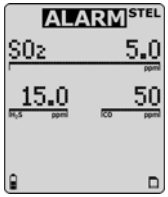


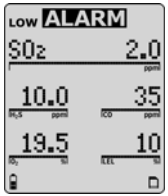
7. The TWA, STEL, low, and high alarm setpoints then display in the following order.

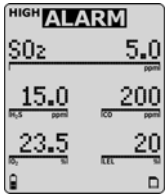
Note

The alarm setpoints may vary by region. Refer to Resetting Gas Alarm Setpoints.



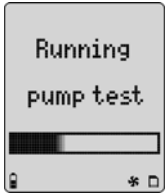




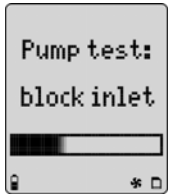


Pump Test (Optional)

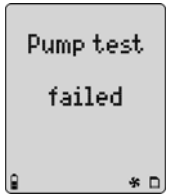
8. If the pump module is attached to the detector, the following screens display.

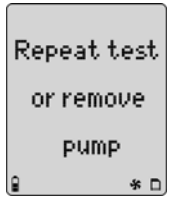


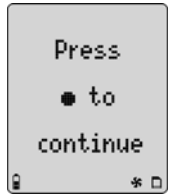
When the following screen displays, block the pump inlet.



If the pump inlet is not blocked within 10 seconds or the pump test fails, the following screens display.

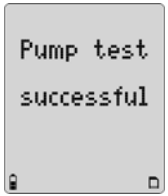




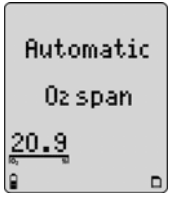


If ◯ is not pressed or the pump is not removed within 25 seconds, the detector performs the pump test again.

If the pump test is successful, the following screen displays and the self-test continues.



9. Unless disabled in user options, the oxygen (O_2) sensor is calibrated automatically.

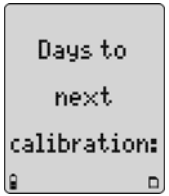


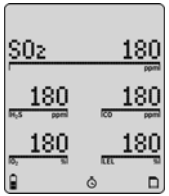
If the span is successful, the detector beeps twice.

Note

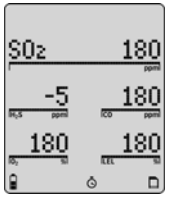
If the automatic O_2 calibration feature has been disabled, **Automatic O_2 span disabled** displays.

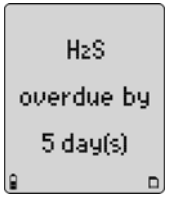
10. Lastly, the number of days remaining before calibration is due displays for all sensors.





If any sensor is past due for calibration, the name of the sensor and the number of days past due display.





Note

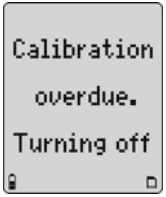
If any sensor is overdue, ⏲ displays continually until calibration is performed.

The self-test is now complete. If **Due-lock** is disabled, the detector enters normal operation.

Due-Lock Is Enabled

The **Due-lock** option is used to ensure that a passcode must be entered when calibration is past due, otherwise the detector automatically deactivates.

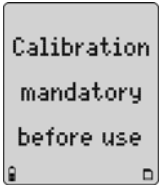
If no passcode is entered, or it is entered incorrectly, the following screen displays.



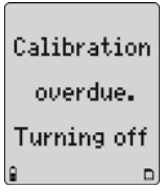
To enable this option, refer to Due-lock in the options menu. Also refer to PassCode Protect.

Force Calibration Is Enabled

If **Force cal** is enabled in the user options menu, calibration is mandatory before the detector enters normal operation. Refer to Force Calibration in Tech Mode to enable/disable, and refer to Calibration and Setting Alarm Setpoints for calibration procedures.

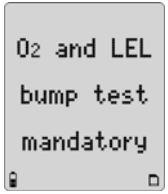


If ◯ is not pressed to start calibration, the following screen displays and the detector deactivates.



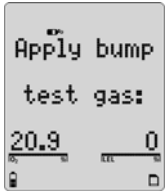
Daily Bump

If the Bump Daily (**Bmp daily**) option is enabled from Tech Mode, the following bump test mandatory screen displays.



The mandatory daily bump test is applicable only to the LEL and O_2 sensors. The bump test must be performed otherwise the detector will deactivate.

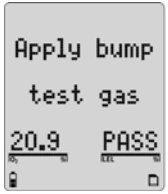
11. When the following screen displays, apply the test gas. Ensure the cylinder icon is flashing before applying gas.



Note

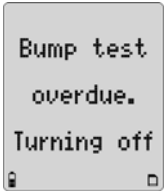
If the bump test is not performed, the detector deactivates.

Successful Bump Test: If the bump test passes, the following screens display.



The detector waits for the sensor(s) to clear (approximately 30 seconds) and then enters normal operation.

Unsuccessful Bump Test: If the bump test is unsuccessful or the bump test is not performed, the following screen displays and the detector deactivates.



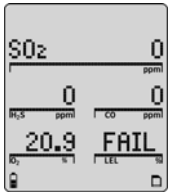
Self-Test Pass

If the detector passes the self-test, it enters normal operation displaying the ambient gas readings.

The detector begins recording the maximum gas exposure (MAX) and calculating the short-term exposure level (STEL) and time-weighted average (TWA) exposures.

Self Test Fail

If a sensor fails, **FAIL** displays above that sensor on the normal operating screen. For possible reasons and solutions, refer to Troubleshooting.



Battery Test

The batteries are tested when the detector is activated and continuously thereafter. The battery power icon displays continually during normal operation. If battery power is low, Low flashes.

Datalogger Operation

⚠ Caution

Do not remove the battery pack while the detector is activated. Doing so will prevent the datalogger from logging correctly.

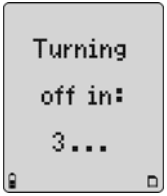
Datalogger operation is automatic and requires no settings. During normal operation the card is tested every 20 seconds.

Note

The MMC/SD icon (🗋) displays continuously on datalogger detectors when the card is inserted. The card is not required for operation of a detector equipped with datalogging.

Deactivating the Detector

To deactivate the detector, press and hold ⓘ while it beeps and flashes to the corresponding countdown.



At the end of the countdown the detector emits an extended beep and flash, and displays **0** before deactivating.

Note

If ⓘ is not held down for the complete countdown, the detector remains activated.

User Options Menu

If the detector is passcode protected, a passcode must be entered to access the user options menu. For more information, refer to Passcode Protect.

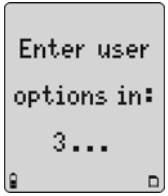
The available user options are as follows:

1. **Exit**;
2. **Options**: backlight, confidence beep, due-lock, latch, passcode, safe, and fast pump;
3. **Sensors**: sensor enable/disable, span gas, STEL period, TWA method, resolution, % vol CH_4, correction factor, and automatic O_2 calibration;
4. **Logger**;
5. **Clock**;
6. **Language**: English, French, German, Spanish, and Portuguese;
7. **Tech mode**: sensors, pump, initialize, forced calibration, daily bump test, and stealth.

Note

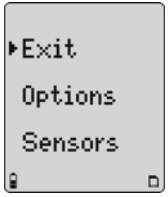
Tech mode is not visible in the user options menu. To access this option, refer to Tech Mode.

To enter the user options menu, press and hold ▲ and ▼ simultaneously as the detector beeps and flashes to the corresponding countdown.



▲ and ▼ must be held down for the entire countdown to enter the user options menu.

When the countdown is complete, the revision/serial number screen displays followed by the options menu.



To scroll through the options, press ▼ or ▲. When the cursor displays beside the desired option, press ◯.

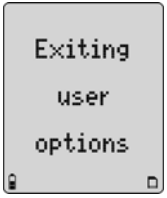
To return to the previous menu, scroll to **Back** and press ◯ or press ⓘ.

Note

If no pushbuttons are pressed for 20 seconds, the detector returns to normal operation.

Exit User Options Menu

To exit the user options menu and return to normal operation, scroll to **Exit** and press ◯. The following screen displays.



Note

The user options menu can also be exited by repeatedly pressing ⓘ until the detector returns to normal operation.

Options Menu

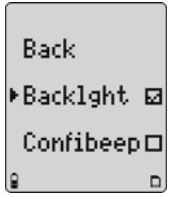
Each feature within the **Options** menu is enabled/disabled by pressing ◯ to toggle the checkbox.

Enabled ☑

Disabled ☐

Backlight

The backlight (**Backlght)** option is used to enable the LCD backlight to activate automatically in low-light conditions.

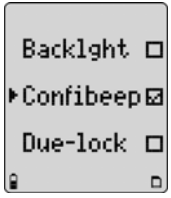


If disabled, the backlight is activated only when the detector is in alarm mode.

The detector is shipped with the backlight option enabled.

Confidence Beep

The confidence beep (**Confibeep**) option is used to provide continuous confirmation that the detector is operating properly. When confidence beep is enabled, the audible alarm beeps once every 10 seconds.



The detector is shipped with the confidence beep option disabled.

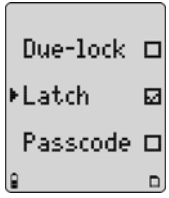
Due-Lock

If **Due-lock** is enabled and a sensor is overdue for calibration upon start-up, the passcode must be entered to access normal operation. If the correct passcode is not entered, the detector deactivates.

The detector is shipped with the due-lock option disabled.

Latched Alarms

If enabled, the latched alarms (**Latch**) option causes the low and high gas alarms (audible, visual, and vibrator) to persist until they are acknowledged. Press ◯ to acknowledge the alarm.



The detector is shipped with the latch option disabled.

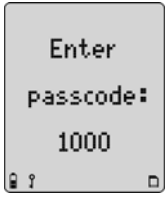
Passcode Protect

The passcode option is used to prevent unauthorized access to the user options menu, the calibration function, and to adjusting the alarm setpoints.

Note

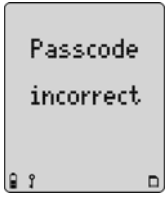
The passcode is provided separately.

If passcode protect is enabled and the **Enter passcode: 1000** screen displays, press ▲ or ▼ to scroll to the correct passcode and then press ◯ to confirm.



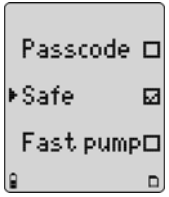
The detector is shipped with the passcode protect option disabled.

If an incorrect passcode is confirmed or ◯ is not pressed within 5 seconds to confirm the correct passcode, **Passcode incorrect** displays. The alarm beeps three times and the detector either resumes normal operation or deactivates.



Safe Display

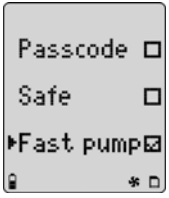
When enabled, the safe option confirms that normal ambient conditions prevail and there are no gas hazards present. When all gas levels are normal or below the alarm setpoints, **Safe** displays continually on the LCD.



The detector is shipped with the safe option disabled.

Fast Pump (Applicable to Pump Module Only)

If the pump module (optional accessory) is attached to the detector, and the sampling hose is longer than 50 ft., the **Fast pump** option must be enabled for maximum flow rate. The detector is shipped with the fast pump option disabled. If enabled, the battery life will deplete sooner.



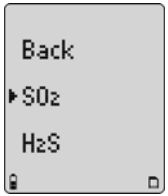
Sensor Configuration

The **Sensor** options provide access to additional options and functions that are available for each sensor.

Depending upon the sensor that is selected, some or all of the following options are available for configuration:

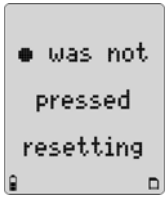
- enabling/disabling a sensor
- setting the span gas value
- adjusting the STEL period
  (not applicable to LEL and O_2 sensors)
- selecting the TWA method
  (not applicable to LEL and O_2 sensors)
- resolution setting
  (not applicable to CO, LEL, and O_2 sensors)
- % vol CH_4 (LEL sensor only)
- Selecting the correction factor
  (LEL and PID sensors only)
- automatic calibration (O_2 sensor only)

From the option menu screen, scroll to **Sensors** and press ◯ to access the following screen.



Press ▲ or ▼ to scroll to the desired sensor. Press ◯ to confirm and to access the menu options that are specific to the selected sensor.

For all sensor options, if a value is changed but not confirmed within 5 seconds, the detector emits an audible alarm and displays the following error message.



The detector retains the previous value and returns to the user options menu.

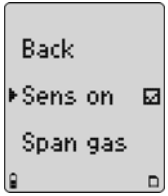
Sensor Enable/Disable

⚠ Warning

Disabling an installed sensor configures the detector to a 1, 2, 3, or 4-gas unit. Protection is no longer provided from the gas targeted by the disabled sensor(s). Disabling a sensor should be performed with extreme caution.

If a sensor fails, disabling the sensor deactivates the fail alarm. The sensor should be replaced and enabled as soon as possible. The detector will function normally with the remaining enabled sensors.

After selecting the desired sensor, the following screen displays.



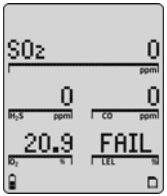
Press ◯ to toggle between enable/disable.

Enabled ☑ A sensor can be enabled at any time.

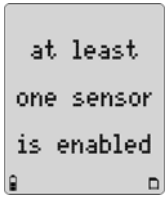
Disabled ☐

If disabled, the readings for the senor do not display when in normal operation.

If a sensor is enabled but it is not installed in the detector, **FAIL** displays above the gas bar of the missing sensor.



If all of the sensors are disabled, the following screens display.



Enable one or more sensors to exit and access normal operation.

Span Gas Value

The **Span gas** option is used to increase/decrease the gas concentration level for calibration (it must match the value on the gas cylinder).

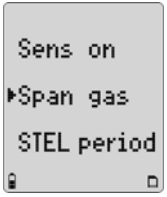
After selecting the sensor, press ▼ to scroll to **Span gas** and press ◯ within 20 seconds to confirm.

Depending upon the sensor selected, a screen similar to one of the two following examples displays. Press ▲ or ▼ to scroll to the desired value and press ◯ within 5 seconds to confirm.

If ◯ is not pressed within 5 seconds to confirm the new value, the detector retains the previous value and returns to the user options menu.

Note

BW recommends that span concentration values be set between specific ranges. Refer to the Calibration and Setting Alarm Setpoints.



STEL Period

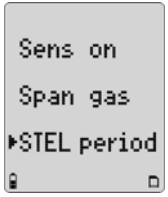
The **STEL period** option is available for every toxic sensor.

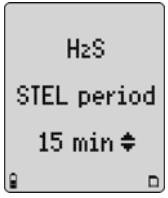
After selecting the desired sensor, press ▼ to scroll to **STEL period** and press ◯ within 20 seconds to confirm.

The STEL period can be set from 5 to 15 minutes. Press ▲ or ▼ to scroll to the required value, and then press ◯ within 5 seconds to confirm.

If ◯ is not pressed within 5 seconds to confirm the new value, the detector retains the previous value and returns to the user options menu.

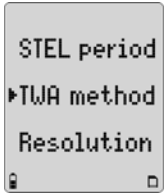
The detector is shipped with the STEL calculation period set to 15 minutes.





TWA Method

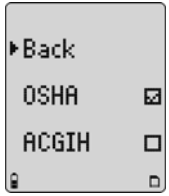
The **TWA** method is used to select either the Occupational Safety and Health Administration (OSHA) or the American Conference of Governmental Industrial Hygienists (ACGIH) calculating method.



OSHA Method: 8 hour moving average.
ACGIH Method: Infinite accumulated average to 8 hours.

After selecting the desired sensor, press ▼ to scroll to **TWA method**. Press ◯ within 20 seconds to confirm.

A check displays in the checkbox of the currently selected method. To select the other method, press ▼ to move the check to other method. Press ◯ to confirm the selection.



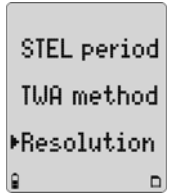
The detector is shipped with the **OSHA** method enabled.

Note

If the TWA method has been changed, the TWA, STEL, and MAX peak values must be reset to ensure the TWA is calculated correctly. Refer to Clearing Gas Exposures.

Resolution

This option is used to display the gas measurement using **Regular** or **Extra** resolution.

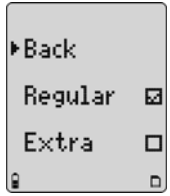


Regular: Displays gas measurement in 1 ppm.

Extra: Displays the gas measurement in 0.1 ppm.

After selecting the desired sensor, press ▼ to scroll to **Resolution**. Press ◯ within 20 seconds to confirm.

A check displays in the checkbox of the currently selected resolution. To select the other resolution, press ▼ to move the check to other resolution. Press ◯ to confirm the selection.



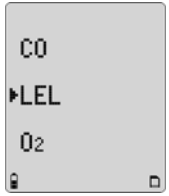
The detector is shipped with **Regular** resolution (1 ppm) enabled.

Note

Regular resolution for O_3 and ClO_2 sensors is 0.1 ppm, while extra resolution is 0.01 ppm. CO, O_2, LEL, and PID sensors do not have resolution settings.

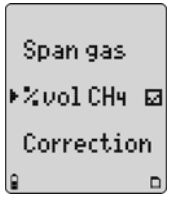
% Vol CH_4 (LEL Sensors Only)

If the **% vol** is enabled, any currently enabled correction factor is ignored and the detector operates assuming a methane (CH_4) calibration.



After selecting the LEL sensor, press ▼ to scroll to **% vol CH_4**. Press ◯ within 20 seconds to confirm.

Press ◯ to toggle between enable and disable.



Confirmation is not required. If no buttons are pushed, after 20 seconds the detector returns to the sensor selection screen. The change is saved automatically.

Enable ☑
Disable ☐

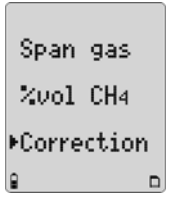
The detector is shipped with **%vol** disabled.

Correction Factor (CF)

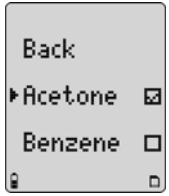
Depending upon the selected sensor, refer to the following sections LEL Sensor or PID Sensor for more information.

LEL Sensor

This option is used to enter compensation factors for hydrocarbons other than methane. The factor can only be applied if the LEL sensor has been calibrated with methane.



After selecting the **LEL** sensor, press ▼ to scroll to **Correction**. Press ◯ within 20 seconds to confirm and access the LEL correction library.



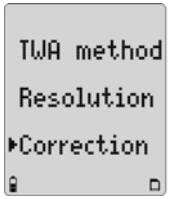
Scroll to the required gas type and press ◯. A check mark displays in the corresponding checkbox. The detector automatically applies the correction factor.

To disable the **Correction** option, press ▼ to scroll to **None** or to **Methane**. A checkmark displays. If required, select a different gas type correction factor.

Custom: To enter a correction factor that is not listed in the library, scroll to **Custom** and press ◯ to confirm. The **Custom LEL correction** screen displays. Press ▲ or ▼ to select the required value, and press ◯ within 5 seconds to confirm.

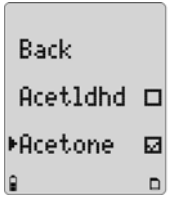
PID Sensor

This option is used to enter compensation factors for selected gas types. The factor can only be applied if the PID sensor has been calibrated with isobutylene.



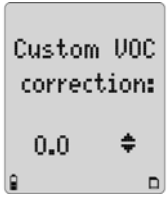
After selecting the **PID** sensor, press ▼ to scroll to **Correction**. Press ◯ within 20 seconds to confirm and access the PID correction library.

Scroll to the required gas type and press ◯. A check mark displays in the corresponding checkbox. The detector automatically applies the correction factor.



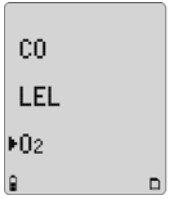
To disable the **Correction** option, press ▼ to scroll to **None** or to **Isobutyl**. A checkmark displays. If required, select a different gas type correction factor.

Custom: To enter a correction factor for a custom PID sensor, scroll to **Custom** and press ◯. Press ▲ or ▼ to scroll to the required value, and press ◯ within 5 seconds to confirm. Refer to Appendix A PID Correction Factor Library for gas types and corresponding correction factor values.



Automatic Oxygen (O_2) Calibration

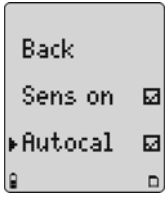
When the **Autocal** option is enabled, it forces the detector to automatically calibrate the oxygen sensor during start-up.



If the **Autocal** option is enabled, ensure the detector is activated in a clean atmosphere only.

From the **Sensor** menu, press ▼ to scroll to **O_2** and press ◯ within 20 seconds to confirm.

Press ▼ to scroll to **Autocal**. Press ◯ to toggle between enable/disable.



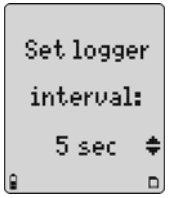
The detector is shipped with the **Autocal** option enabled.

Logger Option

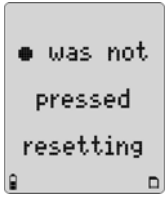
This option is used to set how often the detector records a datalog sample (once every 1 to 127 seconds).

From the user options menu, press ▼ to scroll to **Logger**. Press ◯ within 20 seconds to confirm.

Press ▲ or ▼ to change the current logger rate. When the desired value displays, press ◯ within 5 seconds to confirm the new value.



If ◯ is not pressed within 5 seconds, the following screen displays.

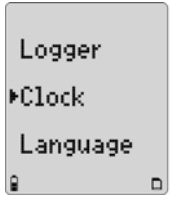


The detector is shipped with the datalogger interval set to 5 seconds.

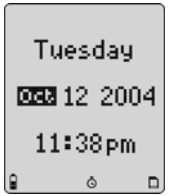
Clock Option

The **Clock** option is used to set/change the date and time.

From the user options menu, press ▼ to scroll to **Clock**. Press ◯ within 20 seconds to confirm.



The screen displays showing the month highlighted indicating it is selected to set.



Press ▲ or ▼ to scroll to the desired month and press ◯ within 20 seconds to confirm. Continue setting the remaining options.

The date/time options are set as follows:
month
day
year
hour
minutes

To bypass and retain the current setting, press ◯.

When the settings are complete, the detector beeps twice and returns to the user options menu.

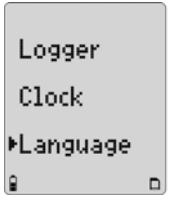
The detector is shipped with the date and time set to Mountain Standard Time (MST).

Language Selection

The detector is shipped with English as the default language. The available languages to select from are as follows:

- French (**Français**)
- German (**Deutsch**)
- Spanish (**Español**)
- Portuguese (**Prtuguês**)

Press ▼ to scroll to **Language** and press ◯ within 20 seconds to confirm.



Press ▲ or ▼ to scroll to the desired language and press ◯. A checkmark displays in the checkbox of the selected language.

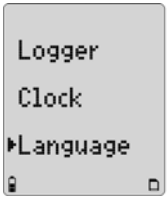
Press ▲ to scroll to **Back** or wait for 20 seconds until the detector returns to the user options menu. The screens now display in the selected language.

Tech Mode

⚠ Warning

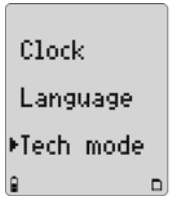
Tech mode should only be accessed by trained personnel.

Tech mode can only be accessed from the **Language** option. Press ▼ to scroll to **Language**. Do not press ◯ until instructed.



In the following order, press and continue to hold each button until **Tech mode** displays.

1. Press and hold ▼ with right index finger.
2. Press and hold ▲ with right middle finger.
3. Press and hold ◯ with left thumb.



Press ◯ to enter **Tech mode**. The options are as follows:

- **Sensors**
- **Pump**
- **Initialize**
- Force calibration (**Force cal**)
- Bump test daily (**Bmp daily**)
- Stealth mode (**Stealth**)
- IR Stealth mode (**IR Stlth**) / optional feature

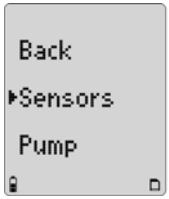
Sensors

⚠ Caution

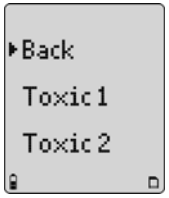
Physically change the sensor prior to entering Tech Mode to reconfigure the sensor type.

When a toxic sensor is physically removed and replaced by another toxic sensor, the detector must be reconfigured to recognize the change.

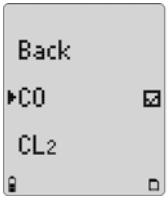
Press ▼ to scroll to **Sensors**. Press ◯ within 20 seconds to confirm and access the toxic sensor menu.



Press ▲ or ▼ to scroll to **Toxic 1** or **Toxic 2** and press ◯ within 20 seconds to confirm.



A corresponding list of toxic sensors displays. A checkbox displays beside the current toxic sensor.

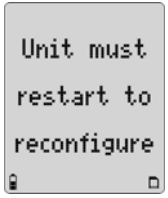


Note

*The **Toxic 1** list includes the PID sensor. The **Toxic 2** list includes the H_2S/CO COSH sensor.*

Press ▲ or ▼ to scroll to the new sensor and press ◯ to confirm. A checkbox displays beside the new sensor. To reconfigure, exit the user options menu.

The following screen displays. The detector deactivates and immediately reactivates. It performs the reconfiguration during the start-up.



The new sensor must also be calibrated as the calibration information returns to the default settings, and the due date automatically displays as **OL** (over limit) while in normal operation.

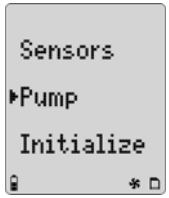
Pump (Optional Accessory)

⚠ Warning

Use only the pump that is provided with the detector. Do not exchange pump modules between detectors.

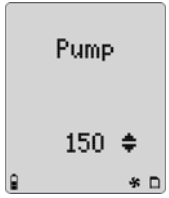
If the detector has been purchased with the pump, the settings do not need to be adjusted. If attaching a new pump module to the detector, the flow rate must be set prior to using the pump.

If required, refer to Installing the Pump Module. Press ▼ to scroll to **Pump** and press ◯ within 20 seconds to confirm.



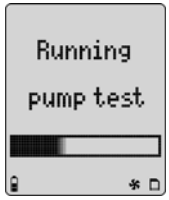
Press ▲ and ▼ to scroll to the required factory-calibrated value (as provided by BW). When the value displays, press ◯ within 5 seconds to confirm.

After selecting a new flow rate, a pump test must be performed.



Exit the user options menu. The detector automatically launches the pump test before returning to normal operating mode.

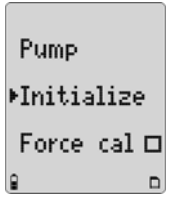
Refer to Pump Test for additional information.



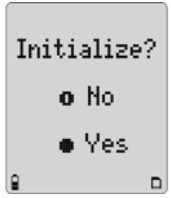
Initialize

The **Initialize** option is used to restore the original factory default settings of the detector.

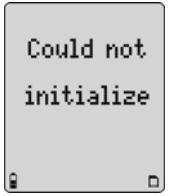
Press ▼ to scroll to **Initialize** and press ◯ within 20 seconds to confirm.



From the **Initialize?** screen, within 5 seconds press ⓘ **No** to exit or press ◯ **Yes** to initialize.

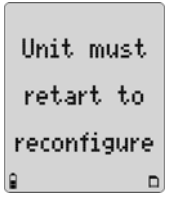


If **No** is selected, the following screen displays and the detector exits the initialize option.



If **Yes** is selected, the following screen displays while performing the initializing process.

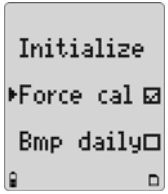
When initializing is complete, the following screen displays.



The detector deactivates and then immediately reactivates. The detector then performs the self-test while it reconfigures to the default settings.

Verify all settings and alarm setpoints, and then calibrate the sensors.

Force Calibration

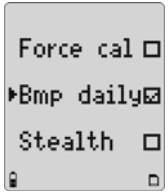


The **Force cal** option is used to force the detector to enter calibration if a sensor is overdue upon start-up. Press ▼ to scroll to **Force cal**.

Press ◯ to toggle between enable/disable.

The detector is shipped with the **Force cal** option disabled.

Bump Daily



The **Bmp daily** option is used to force the detector to perform a daily bump check to ensure that it is responding to the test gas.

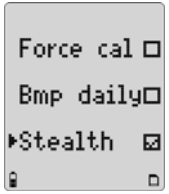
Press ▼ to scroll to **Bmp daily**. Press ◯ to toggle between enable/disable.

The detector is shipped with the **Bmp daily** option disabled. **Oxygen and LEL Sensors:** Daily bumps are required whenever the detector has been reactivated following 00:00 hours (midnight).

Stealth Mode

Note

*The **Stealth** and **IR Stlth** options cannot be enabled simultaneously.*



The **Stealth** option is used to disable the backlight, visual alarms, and audible alarms when concealment is required. Only the vibrator and the LCD activate during an alarm condition.

Press ▼ to scroll to **Stealth**. Press ◯ to toggle between enable/disable.

The detector is shipped with the **Stealth** option disabled.

IR Stealth Mode (Optional)

This is an optional feature and must be factory ordered.

Note

*The **Stealth** and **IR Stlth** options cannot be enabled simultaneously.*

The **IR Stlth** option operates the same as the **Stealth** option except that it activates infrared LEDs that are located in the right alarm bar. If this option is included on the detector, press ▼ to scroll to **IR Stlth**. Press ◯ to toggle between enable/disable.

The detector is shipped with the **IR Stlth** option disabled.

Alarms

The following table describes the detector alarms and corresponding screens.

During an alarm condition, the detector activates the backlight and displays the current ambient gas reading.

If more than one type or level of alarm exists simultaneously, a multi-gas alarm will result.

To change the factory-set alarm setpoints, refer to Calibration and Setting Alarm Setpoints.

Table 6. Alarms

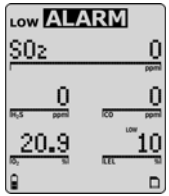
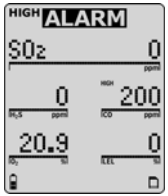
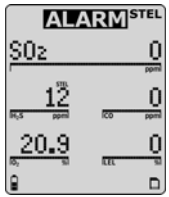
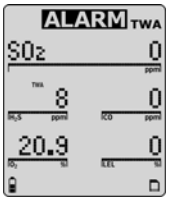
Alarms	Display`	Alarms	Display
Low Alarm: • Fast beep • Slow flash • ALARM and target gas bar flash • Vibrator alarm activates		**High Alarm:** • Constant beep • Fast flash • ALARM and target gas bar flash • Vibrator alarm activates	
STEL Alarm: • Constant beep • Fast flash • ALARM and target gas bar flash • Vibrator alarm activates		**TWA Alarm:** • Fast beep • Slow flash • ALARM and target gas bar flash • Vibrator alarm activates	

Table 6. Alarms (cont.)

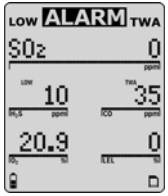
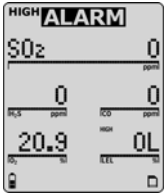
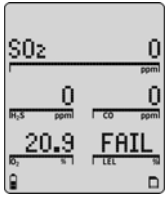
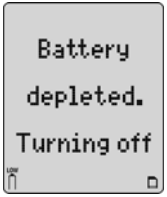
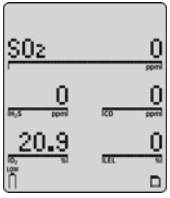
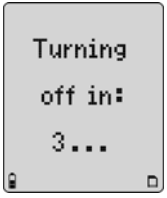
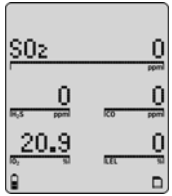
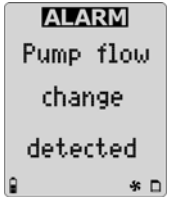
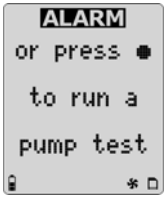
Alarms	Display	Alarms	Display
Multi-Gas Alarm: • Alternating low and high alarm beep and flash • ALARM and target gas bars flash • Vibrator alarm activates		**Over Range Alarm:** **(Over Level Exposure)** • Fast beep and flash • ALARM and target gas bar flash • Vibrator alarm activates	
Sensor Alarm: • One beep every 15 seconds • **FAIL** flashes above the failed sensor		**Automatic Shutdown Alarm:** • Eight beeps and flashes • LOW displays • Vibrator alarm temporarily activates	
Low Battery Alarm: • One beep and two flashes every 25 seconds • LOW flashes		**Normal Shutdown:** • Three beeps and flashes	

Table 6. Alarms (cont.)

Alarms	Display	Alarms	Display
Confidence Beep: • Two fast beeps every 10 seconds		**MMC Fail Alarm:** • One beep every 5 seconds • 🗋 flashes	

Alarms	Displays
Pump Alarm: • Two fast beeps and alternating flashes • Vibrator alarm activates • ALARM and flash	  

Note

If the latched alarm function is activated, the audible and visual alarms continue to beep and flash until the alarm condition is acknowledged. To acknowledge a latched alarm, press ◯. The alarms cannot be deactivated if an alarm condition exists.

If the stealth option is enabled, the detector only vibrates during an alarm; the audible and visual alarms are disabled.

Gas Exposures Computed

⚠ Warning

To avoid possible personal injury, do not deactivate the detector during a work shift. TWA and STEL readings reset if the detector is deactivated for more than 5 minutes.

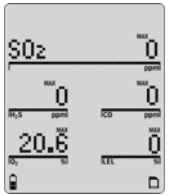
Table 7. Computed Gas Exposures

Gas Exposure	Description
TWA (toxic only)	Time-weighted average (TWA) based on accumulated exposure to toxic gases averaged over a work day according to OSHA or ACGIH method.
STEL (toxic only)	Short-term exposure limit (STEL) to gas based on a 5-15 minute user selectable period.
Maximum* (peak)	Maximum (MAX) concentration encountered during work shift.

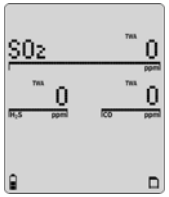
*For oxygen, it is the highest or the lowest concentration encountered.

Viewing Gas Exposures

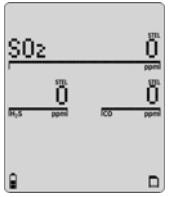
Press and hold ◯ until the MAX gas exposures screen displays.



The TWA gas exposures display next.



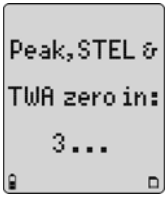
Lastly, the STEL gas exposures display.



Clearing Gas Exposures

The exposures automatically clear after 5 minutes of the detector being deactivated.

To clear the MAX, TWA, and STEL exposure readings immediately, press and hold ◯ and ▲ simultaneously. The detector displays the following screen during the countdown.



Note

Hold ◯ and ▲ for the entire countdown, otherwise the MAX, TWA, and STEL exposure readings will not clear.

Gas Alarm Setpoints

The gas alarm setpoints trigger the gas alarms and are described in Table 8.

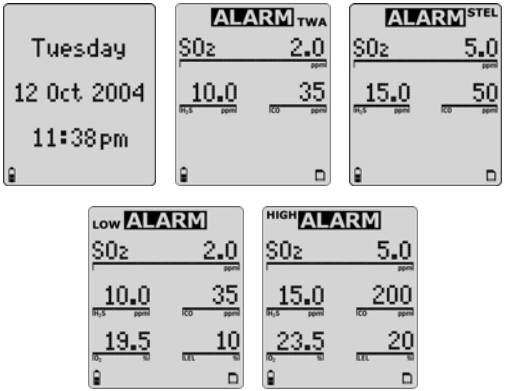
Table 8. Gas Alarm Setpoints

Alarm	Condition
Low alarm	*Toxics and combustibles:* Ambient gas level above low alarm setpoint. *Oxygen:* Ambient gas level may be set above or below 20.9%.
High alarm	*Toxics and combustibles:* Ambient gas level above high alarm setpoint. *Oxygen:* Ambient gas level may be set above or below 20.9%.
TWA alarm	*Toxic only:* Accumulated value above the TWA alarm setpoint.
STEL alarm	*Toxic only:* Accumulated value above the STEL alarm setpoint.
Downscale alarm	*Toxic:* If sensor reading is negative (half of the TWA setpoint). *LEL:* If sensor reading is negative (half of the low alarm setpoint).
Multi-gas alarm	Two or more gas alarm conditions.

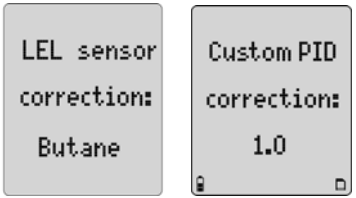
Viewing the Alarm Setpoints

To view the current alarm setpoints for all of the sensors, press ▲ during normal operation.

The TWA, STEL, low, and high alarm setpoint screens display in the following order:



If a correction factor has been applied to a sensor, one of the following screens display indicating the sensor and gas type.



Resetting Gas Alarm Setpoints

Note

Standard factory alarm setpoints vary by region.

The following table lists the factory alarm setpoints according to the Occupational Safety and Health Association (OSHA) settings.

Table 9. OSHA Sample Factory Alarm Setpoints

Gas	TWA	STEL	Low	High
O_2	N/A	N/A	19.5% vol.	23.5% vol.
LEL	N/A	N/A	10% LEL	20% LEL
CO	35 ppm	50 ppm	35 ppm	200 ppm
H_2S	10 ppm	15 ppm	10 ppm	15 ppm
PH_3	0.3 ppm	1.0 ppm	0.3 ppm	1.0 ppm
SO_2	2 ppm	5 ppm	2 ppm	5 ppm
Cl_2	0.5 ppm	1.0 ppm	0.5 ppm	1.0 ppm
NH_3	25 ppm	35 ppm	25 ppm	50 ppm
NO_2	2.0 ppm	5.0 ppm	2.0 ppm	5.0 ppm
HCN	4.7 ppm	10.0 ppm	4.7 ppm	10.0 ppm
ClO_2	0.1 ppm	0.3 ppm	0.1 ppm	0.3 ppm
O_3	0.1 ppm	0.1 ppm	0.1 ppm	0.1 ppm
VOC	50 ppm	100 ppm	50 ppm	100 ppm

To change the factory-set alarm setpoints, refer to Calibration and Setting Alarm Setpoints.

Note

*To disable an alarm, set the alarm setpoint to **0** (zero).*

Stopping a Gas Alarm

The low and high alarms stop when the ambient gas level returns to below the low alarm setpoint.

Note

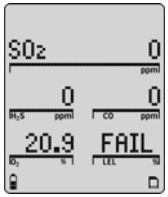
If alarms are set to latch, press ◯ to reset the alarms.

The TWA and STEL alarms can be stopped either by

- clearing the MAX, TWA, and STEL peak exposures (refer to Clearing Gas Exposures), or
- deactivating the detector for 5 minutes (minimum) and then reactivating it again.

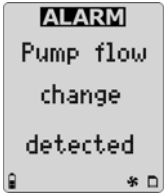
Sensor Alarm

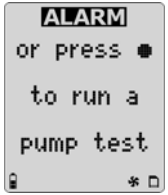
The detector tests for missing or defective sensors during the activation self-test. If a sensor fails the self-test, the detector displays **FAIL** above the failed sensor. Refer to Troubleshooting.



Pump Alarm

The external pump draws air over the sensors continually. If the pump stops operating or becomes blocked, the detector activates the pump alarm. The following screens display.





The pump alarm continues until the blockage is cleared or it is acknowledged by pressing ◯. If ◯ is pressed, the detector automatically launches a pump test to reset the pump module.

Refer to Pump Test for more information. If the pump test is successful, the detector returns to normal operation, otherwise the pump alarm continues.

Low Battery Alarm

The detector tests the batteries upon activation and continuously thereafter. Battery power is continually displayed during normal operation. If the battery voltage is low, the detector activates the low battery alarm.

The low battery alarm continues until the batteries are replaced/charged, or until the battery power is almost depleted. If the battery voltage becomes too low, the detector deactivates.

Note

Typically, the low battery alarm continues for 30 minutes before the detector automatically deactivates.

Automatic Shutdown Alarm

If the battery voltage is in immediate danger of falling below the minimum operating voltage, the audible alarm beeps eight times and the visual alarm flashes eight times. After 3 seconds, the LCD deactivates and the detector exits normal operation.

To replace or charge the batteries, refer to Replacing/Charging the Batteries.

Calibration and Setting Alarm Setpoints

Guidelines

When calibrating the detector, adhere to the following guidelines:

- Recommended gas mixture:
  CO: 50 to 500 ppm balance N_2
  H_2S: 10 to 100 ppm balance N_2
  PH_3: 1 to 5 ppm balance N_2
  SO_2: 10 to 50 ppm balance N_2
  Cl_2: 3 to 25 ppm balance N_2
  NH_3: 20 to 100 ppm balance N_2
  NO_2: 5 to 50 ppm balance N_2
  HCN: 5 to 20 ppm balance N_2
  ClO_2: 0.1 to 1.0 ppm balance N_2
  O_3: 0.1 to 1.0 ppm balance N_2
  VOC: 100 ppm isobutylene
  LEL: 10 to 100% LEL or 0.5 to 5% by vol. methane balance air
  O_2: clean air, 20.9 %
- CG-Q58-4 and CG-Q34-4 calibration gas (4-gas mix) are available from BW Technologies. See the section, Replacement Parts and Accessories.

- Calibration accuracy is never better than the calibration gas accuracy. BW Technologies recommends a premium-grade calibration gas. Gases with National Institute of Standards and Technology (NIST) traceable accuracy improves the validity of the calibration. Do not use a gas cylinder beyond its expiration date.
- Calibrate a new sensor before use. Install the sensor, activate the detector, and allow the sensor to stabilize before starting calibration.

  Used sensor: 60 seconds
  New sensor: 5 minutes
- Calibrate the detector at least once every 180 days (calibrate HCN detectors at least once every 90 days) depending upon use and sensor exposure to poisons and contaminants.
- Calibrate the detector if the ambient gas varies during start-up.
- Calibrate the sensor before changing the alarm setpoints.
- Calibrate only in a clean atmosphere that is free of background gas.
- To disable an alarm, set the alarm setpoint to **0** (zero).
- If the **Auto cal** option is enabled, the oxygen (O_2) sensor calibrates automatically every time the detector is activated. Activate the detector in a normal (20.9% oxygen) atmosphere.
- After activating the detector, allow it to stabilize for 1 minute before performing a calibration or bump test.
- If a certified calibration is required, contact BW Technologies.

  Note

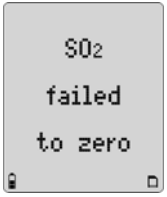
  A generator must be used for O_3 and ClO_2 sensors.

Diagnostics Protection

The detector tests the ambient air (auto zero) and the test gas that is applied (auto span) to ensure it meets expected values.

Auto zero sets the zero-gas level of the sensor. If ambient gas is present, the zero level will be incorrect.

If excessive gas is present, the detector displays an error message and lists the affected sensor.



In auto span, if target gas is not detected or does not meet expected values, a message displays that the detector is exiting calibration mode. The detector retains the previous set values.

Applying Gas to the Sensors

The calibration cap and hose are shipped with the detector. Refer to Table 10 and Figure 3 for installation.

Note

The calibration cap can only be used during the calibration span process.

Table 10. Applying Gas to the Sensors

Item	Description
1	Detector and calibration cap
2	Calibration hose
3	Regulator and gas cylinder

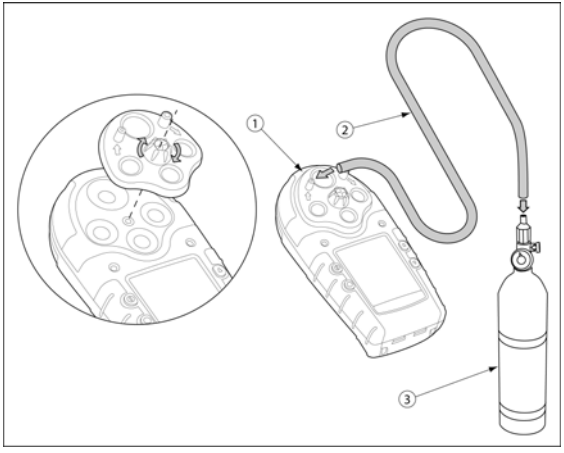


Figure 3. Applying Gas to the Sensors

Calibration Procedure

To calibrate the detector and set the alarm setpoints, perform the following procedures.

Note

To bypass a step during the calibration process (after auto zero), press ⓘ. Calibrate O_2 in clean air.

Start Calibration

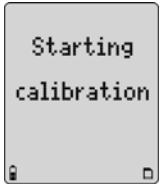
Note

Verify that the calibration gas being used matches the span concentration value(s) that are set for the detector. Refer to _Span Gas Value_.

Correction factors are not applied during calibration. Correction factors that were set prior to calibration are restored when the detector returns to normal operation.

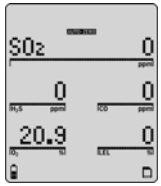
1. To enter calibration, in a clean atmosphere press and hold ◯ and ▼ simultaneously as the detector beeps, flashes, and vibrates to the corresponding countdown.

   The following screen displays to indicate that calibration mode has been entered.



Auto Zero and Oxygen (O_2) Sensor Calibration

2. AUTO-ZERO flashes while the detector automatically zeroes the toxic and combustible sensors, and calibrates the O_2 sensor.



Note

Do not apply calibration gas during this process, otherwise the auto zero step will fail.

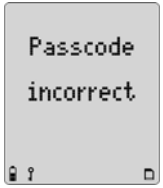
Passcode Protect Activated (Optional)

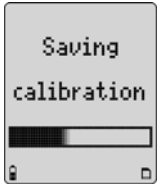
When auto zero is complete and if the passcode protect option is enabled, the detector prompts for the passcode.

The passcode must be entered to proceed. If required, refer to Passcode Protect in User Options menu.

3. Press ▲ or ▼ to scroll to the correct passcode. When it displays, press ◯ within 5 seconds to confirm. If the correct passcode is entered, the detector beeps twice and proceeds to the auto span.

Incorrect Passcode: If the passcode is incorrect or is not confirmed within 5 seconds by pressing ◯, the following screens display.

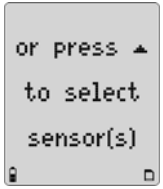


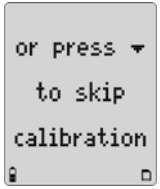


The detector saves the calibration and returns to normal operation.

Auto Span

After auto zero and the correct passcode is entered (if required), the following three screens display.





Note

Span sensors in the following order:

- *Exotics (NH_3, ClO_2, O_3, and Cl_2)*
- *Single gas*
- *Quad gas (H_2S, CO, LEL, and O_2)*
- *PID*

Apply Span Gas Now

Note

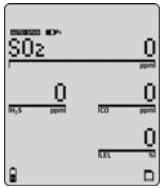
A generator must be used for O_3 and ClO_2 sensors.

- ***ClO_2:*** *BW recommends that a Tedlar bag be used as a buffer between the generator and the detector (while using the calibration cap) to regulate the flow rate to ensure accurate readings.*
- *Set the generator to 0.5 ppm at a flow rate of 0.5 l/min. (liter per minute).*
- *Allow the Tedlar bag to fill for several minutes before initiating calibration.*
- ***O_3:*** *Calibrate only using the calibration cap. Do not use a Tedlar bag.*

Depending upon the gas cylinder being used, one or all four sensors can be calibrated at one time.

4a. Attach the calibration cap and apply gas to the sensor(s) at a flow rate of 500 ml/min. (1000 ml/min. for NH_3 and Cl_2). Refer to Figure 3. Applying Gas to Sensors.

flashes as the detector initially detects the calibration gas.



After 30 seconds the detector beeps and stops flashing. AUTO-SPAN flashes while spanning the sensors until the detector has attained a sufficient level of the expected gas.

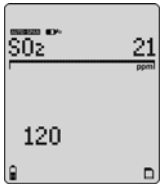
Refer to Table 11 for times required to span.

Table 11. Time Required to Span

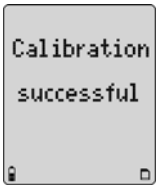
Gas Type	Time Required to Span
Most toxic gases	2 minutes
Exotic toxic gases	5 minutes
LEL (combustibles)	30 seconds
PID gases	2 minutes

Insufficient Level: If a sensor does not attain a sufficient level of expected gas, it is cleared from the LCD and is not spanned.

While the detector is spanning the sensor(s), a countdown of time remaining displays in the lower left of the screen.



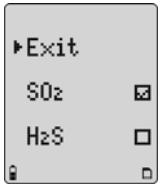
When the span is complete, the following screen displays.



Proceed to Successful Span step #5. If problems occur during the span, refer to Unsuccessful Span for possible solutions.

Select Sensor

4b. If ◯ is pressed to select **Sensor**, the following screen displays. The list of sensors will vary, depending upon the sensors that are installed.



Note

Only sensors that are selected are accepted for the current span.

Ensure that the checkbox is enabled for the sensor that is to be spanned.

Press ⓘ to exit. The **Apply span gas to calibrate** screen then displays. Refer to back to step #4a.

Skip Calibration

4c) If ⓘ is pressed, proceed to step #6.

Successful Span

If the sensor(s) has spanned successfully, the audible alarm beeps three times and the following screens display.

5. If there are more sensors to span, remove the existing calibration gas cylinder and connect the next cylinder.

   Press ▲ and apply gas to span the other sensor(s).

   Or

   Press ▼ to end the span and proceed to step #6 to set the calibration due dates.

If all of the sensors have successfully spanned, the following screen displays prior to continuing with the calibration process.

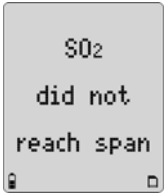
Unsuccessful Span

If the sensor(s) did not span successfully, refer to the following sections for possible solutions:

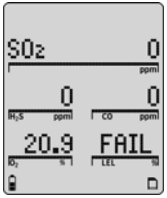
- Failed Span
- No Gas Detected
- Did Not Reach Target Span
- Large Span

Failed Span

If a sensor fails the span, the following error message displays.



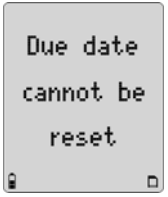
If the sensor is not recalibrated, the sensor displays as **FAIL** in normal operation the next time the detector is activated.



If all of the sensors fail the span, the following screen displays.

Press ⓘ to exit and then restart calibration in an atmosphere that is clear of the targeted gases. If the span fails a second time, restart the detector to test the sensors.

If all of the sensors fail the span, the due dates for calibration cannot be set.



If the detector fails to span the sensors, confirm the following:

- Ensure gas is being applied to the sensor.
- Ensure the sensors detect at least one-half of the expected gas concentration in the first 30 seconds.
- Ensure the gas concentration does not drop below one-half of the expected gas level during the span.

If the detector still fails to span the sensor(s), repeat the calibration using a new gas cylinder.

If the span is still unsuccessful, replace the sensor(s). Refer to Replacing a Sensor or Sensor Filter.

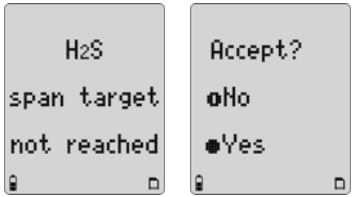
No Gas Detected

If the detector does not detect any gas within 30 seconds, the following screens display.

Press ▲ to reapply gas using another gas cylinder, or press ▼ to end the span and proceed to step #6.

Did Not Reach Target Span

If the span did not reach the target span as set in the user options menu (Span Gas Value) for the selected sensor, the detector displays the following screens.



Not reaching the target span can be the result of

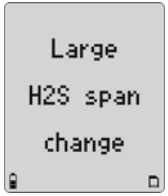
- a problem with the span gas,
- the gas cylinder being past the expiry date, or
- a problem with the sensor.

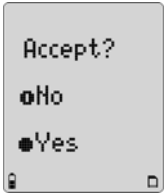
Accept Current Span: If the span gas, gas cylinder, and sensor appear to be correct, press ◯ to accept the current span.

Reject Current Span: Press ⓘ to reject. Verify the span gas and the detector settings, and then recalibrate the sensor.

Large Span

If the span adjustment is unusually large (more than 15%), the following screens display.





Ensure the calibration gas cylinder being used is correct and that the span concentration value(s) (refer to Span Gas Value) of the detector matches the value(s) of the gas cylinder.

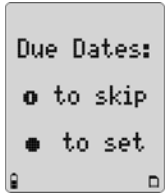
Adjustment Expected: If the calibration adjustment is expected, press ◯ to accept the span.

Adjustment Not Expected: If the calibration adjustment is not expected or the span gas value does not match the calibration gas cylinder, press ⓘ to reject the span and calibrate that sensor again.

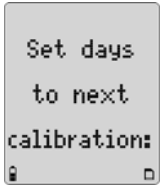
Setting the Calibration Due Date

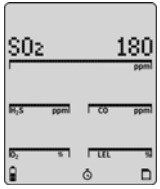
When the span is complete, the calibration due date can be set for each sensor that has spanned successfully.

The following screen displays.



6. Press ◯ to set the calibration due dates. The following screens display.





Note

*Unless a new due date value is entered, the detector automatically resets to the previously entered number of days (eg. **180**) for each sensor that has spanned successfully.*

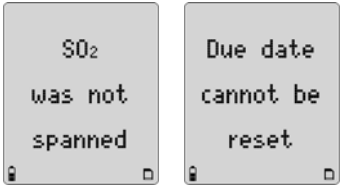
Or

Press ⓘ to bypass and proceed to step #9.

The calibration due dates are set in the following order:

- Toxic 1
- Toxic 2 (H_2S and CO)
- LEL
- O_2

If an attempt is made to change the due date of a unsuccessfully spanned sensor, the following screens display.



The detector then automatically proceeds to the next sensor.

7. To change the calibration due date (1-365 days), press ▼ or ▲ until the new value displays. Press ◯ within 5 seconds to confirm.

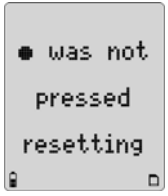
   Or

   Press ⓘ to bypass a sensor and proceed to the next sensor.

   The detector automatically proceeds to the next sensor to set the calibration due date.

Note

If a value is changed but ◯ is not pressed within 5 seconds to confirm, the following screen displays.



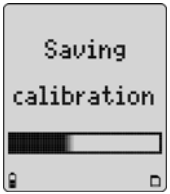
The previous value is automatically retained. The detector proceeds to the next sensor calibration due date.

8. Repeat step #7 to set the calibration due date for the remaining sensors.

9. Press ◯ to set the alarm setpoints and proceed to the following section Alarm Setpoints.

   Or

   Press ⓘ to bypass setting the alarm setpoints and proceed to Finish Calibration.



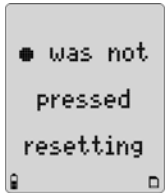
Alarm Setpoints

Factory alarm setpoints may vary by region. Refer to Resetting Gas Alarm Setpoints for an example. Alarms can be set to any value within the detection range of the selected sensor. Refer to Specifications.

Note

To disable an alarm setpoint, set it to **0** (zero).

When setting alarm setpoints, if the new setpoint is not confirmed within 5 seconds by pressing ◯, the following screen displays.



The previous setpoint is retained and the detector proceeds to the next setpoint.

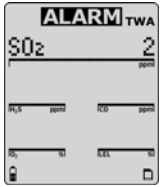
The setpoints are set in the following order:

- TWA (if applicable)
- STEL (if applicable)
- low
- high

To bypass a setpoint, press ◯ to save the current value and proceed to the next setpoint.

Setting the TWA Alarm Setpoint

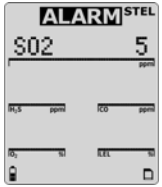
The current TWA alarm setpoint displays for the selected sensor (if applicable).



10. Press ▼ or ▲ to change the value for the TWA alarm setpoint. When the required value displays, press ◯ to confirm.

Setting the STEL Alarm Setpoint

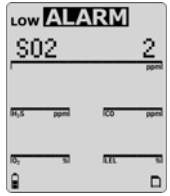
The current STEL alarm setpoint displays for the selected sensor (if applicable).



11. Press ▼ or ▲ to change the value for the STEL alarm setpoint. When the required value displays, press ◯ to confirm.

Setting the Low Alarm Setpoint

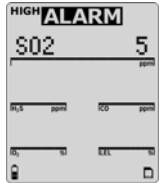
The current low alarm setpoint displays for the selected sensor.



12. Press ▼ or ▲ to change the value for the low alarm setpoint. When the required value displays, press ◯ to confirm.

Setting the High Alarm Setpoint

The current high alarm setpoint displays for the selected sensor.

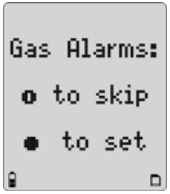


13. Press ▼ or ▲ to change the value for the high alarm setpoint. When the required value displays, press ◯ to confirm.

Setting the Remaining Alarm Setpoints

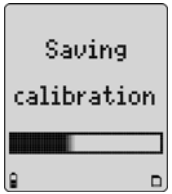
14. Repeat steps #10-13 to set alarm setpoints for the remaining sensors. The audible alarm beeps four times when the alarm setpoint function is complete.

    When the due dates have been set for all required sensors, the detector emits two quick beeps and then proceeds to the gas alarms setpoints screen.



Finish Calibration

The detector displays the following to indicate that the calibration process is complete.



The detector then returns to normal operation.

Verification

After calibration is complete and the detector is in normal operating mode, test it using a gas cylinder other than the one used for calibration. The gas concentration should not exceed the sensor's detection range. Confirm that the LCD displays the expected concentration values.

To ensure that the reading are accurate, apply the test gas for the same amount of time as was applied to the sensor when it was calibrated.

Example: SO_2 span time 2 minutes therefore, apply test gas for 2 minutes.

Attaching the Accessories

Installing the Pump Module

The BW motorized pump module is an optional accessory for the detector. The pump module is designed to be used with the sample probe to test for gases in confined spaces.

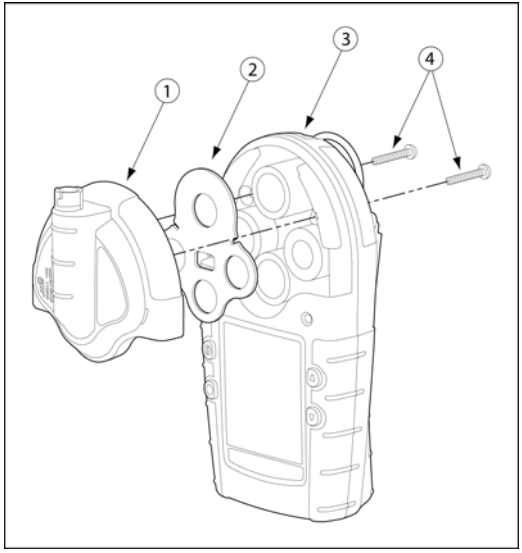


Figure 4. Installing the Pump Module

Table 12. Installing the Pump Module

Item	Description
1	Motorized pump module
2	Sensor filter
3	Detector
4	Machine screws (2)

1. To install the pump module, deactivate the detector.
2. Remove the two machine screws and the sensor cover. Remove the sensor filter from the sensor cover and insert it into the pump module.
3. Attach the pump module to the detector and replace the two machine screws.
4. Activate the detector. The detector performs the start-up self-tests and the pump test. Refer to Pump Test.
5. If the pump has been purchased separately (not included with the detector), the pump flow rate must be set prior to using the pump. Refer to Pump in the Tech Mode section.

Note

Do not exchange pump modules between detectors.

Attaching the Sample Probe

The sample probe is used to safely test for gas in confined spaces before entering.

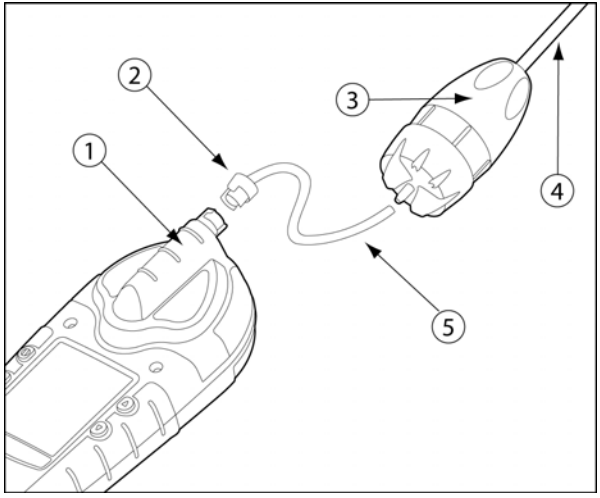


Figure 5. Attaching the Sample Probe

Table 13. Attaching the Sample Probe

Item	Description
1	Motorized pump module
2	Connector
3	Sample probe
4	Sample probe 10 in. tubing (custom lengths can be ordered)
5	Flexible connector hose

⚠ Warning

The sample probe must be used with the pump module only. Ensure that all connections are secure before sampling.

1. Make all of the required connections as illustrated in Figure 5 Attaching the Sample Probe.
2. Activate the detector.

⚠ Warning

If the length of the tubing is 50 ft. or longer, the Fast Pump option must be enabled prior to sampling. Refer to Fast Pump in user options.

3. Insert the sample probe tubing into the confined space.

   Depending upon the length of the tubing and the type of gas in the confined space, allow a minimum of 3 seconds per ft. of hose to ensure the readings stabilize before entering the area.

   Example: 50 ft. = 2.5 minutes

Datalogger

Detectors that are equipped with the datalogger option record information that can be compiled to create a report.

Datalog

Datalog information is recorded based on the sampling rate that is set in the **Logger** option. The detector can be set to record a datalog sample once every 1 to 127 seconds.

To set the sample rate, refer to Logger Option in the user options.

The following information is recorded in a datalog:

- Date and time
- Serial number of the detector
- Type of gas the detector monitors
- Gas reading(s) that display
- STEL and TWA readings
- Sensor status
- Detector status
- Passcode protect enabled/disabled
- STEL period setting
- Confidence beep enabled/disabled
- Automatic backlight enabled/disabled
- Stealth mode is enabled/disabled
- Latching alarm enabled/disabled
- Calibration past due user option enabled/disabled
- Language the detector is set to display

MultiMediaCard (MMC) Compatibility

An Infineon 32 MB MMC Flash Memory card is supplied with the detector.

⚠ Caution

To ensure the Intrinsic Safety rating of the detector, use only the 32 MB Infineon MMC.

To purchase additional Infineon 32 MB MMCs, refer to Replacement Parts and Accessories.

Inserting the MMC/SD Card

To insert the MultiMediaCard/Secure Digital card (MMC/SD) into the detector, refer to Table 14, Figure 6, and the following procedures.

Table 14. Removing the MMC/SD Card

Item	Description
1	Back of detector
2	Battery pack
3	MMC/SD card

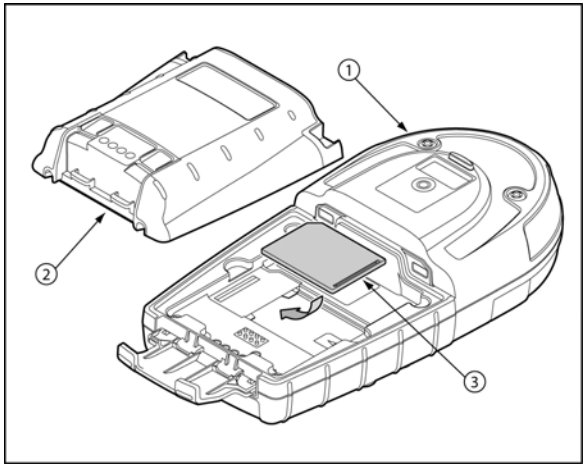


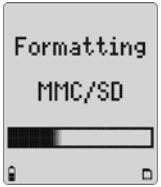
Figure 6. Installing and Removing the MMC/SD

1. Deactivate the detector.
2. Release the latch and remove the battery pack. If required, refer to Figure 3.
3. Insert the MMC/SD pins face down.
4. Replace the battery pack and secure the latch.

MMC/SD Troubleshooting

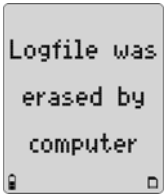
The MMC or secure digital (SD) card is not required for operation in detectors equipped with datalogging. However, the following two screens display if the card is not inserted.

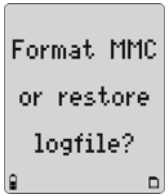
A new MMC is automatically formatted when it is inserted in the detector. When the detector is activated, it begins the self-test and then displays the following screen.



Restoring Datalog Files

If the MMC has been accidentally reformatted or erased by the computer application, the following screens display when the card is inserted into the detector.





⚠ Warning

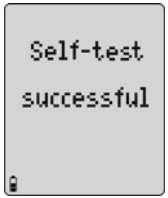
Only erased data files can be restored using the detector. Computer applications sometimes write data over erased files and that data cannot be restored by the detector.

Always create back up files on the computer.

To restore the logfile, complete the following:

1. From the detector, press ▼ to restore the log file. The following screen displays.

If the detector successfully restores the log file, the following screen displays and the start-up tests continue.



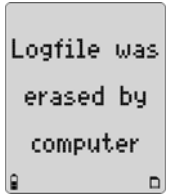
2. Using the computer, verify that the logfile has been restored. When the normal operating screen displays, deactivate the detector.
3. Remove the MMC and insert it into the card reader.
4. From the computer desktop, double-click **My Computer** to view the list of drives.
5. Double-click the **Removable Disk** drive to access **LOGFILE0.CSV**. Open the log file and verify that the data has been restored.

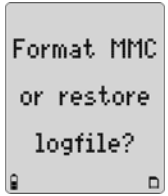
   If **LOGFILE0.CSV** does not display, ensure that the MMC is installed in the card reader correctly and that all connections are secure.
6. After verifying that the log file has been restored, re-insert the MMC into the detector.

Reformatting the MMC

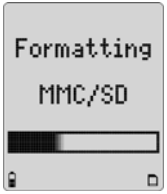
To reformat the MMC, complete the following:

1. Insert the MMC into the card reader.
2. From the computer desktop, double-click **My Computer** to view the list of drives.
3. Double-click the **Removable Disk** drive to access **LOGFILE0**.
4. Select **LOGFILE0** and delete.
5. Reinsert the MMC into the detector.
6. Activate the detector. The start-up self-test begins and the following screens display.





7. Press ▲ to format the MMC. The following screen displays.



For any additional MMC/SD errors, refer to Troubleshooting.

Import Datalogs to FleetManager

Note

Refer to the following minimum requirements before importing datalogs to FleetManager.

Minimum PC Requirements

- 500 MHz Pentium (or equivalent)
- 100 MB free hard disk space
- Microsoft® Windows 98 or later
- USB port

Using MicroDock II to Import to FleetManager

Note

If the detector is used with the MicroDock II Automatic Test and Calibration Station to import datalogs to FleetManager, refer to the MicroDock II User Manual for complete instructions.

Using a Card Reader to Import to FleetManager

To import a datalog file from the detector to FleetManager, complete the following:

1. Deactivate the detector.
2. Release the latch and remove the battery pack.
3. Remove the MMC/SD from the detector. Refer to Figure 6 and Table 14.
4. Connect the card reader to the USB port on the computer.
5. Insert the MMC into the card reader (ensure that the pins face down).

6. From the computer desktop, click **FleetManager**. A popup displays. Select one of the following:
   - **Create New Database**
   - **Use Existing Database**
7. Another window opens. Select the required database.
8. From the FleetManager window, click **Import** from the left menu bar.
9. A popup displays: **No MicroDock devices found**. Click **OK**.

   A browser window opens **Key in Data Log File Path**. If required, expand the window.
10. Press [...] to browse to **My Computer**.
11. From **My Computer**, select **Removable Disk** drive.
12. From the **Removable Disk** drive, double-click **LOGFILE0**.

    For additional information and procedures, refer to the Fleet Manager Deluxe CD and FleetManager on-line help.

View Datalog Files in Spreadsheets

The datalog files can be loaded from the MMC/SD into most spreadsheet applications using a card reader. Compatible software applications are

- Microsoft® Excel 98 or later,
- Quattro Pro,
- Lotus 1-2-3,
- Microsoft® Access, and
- Microsoft® Word.

To view a datalog file in a software spreadsheet, complete the following:

1. Deactivate the detector and remove the MMC/SD (refer to Figure 6).
2. Insert the MMC/SD into the card reader.
3. From the computer desktop, double-click **My Computer** to view the list of drives.
4. Double-click **Removable Disk** drive.
5. Double-click **LOGFILE0**.

   Refer to the following three tables for a spreadsheet example and definitions.

Example of a Datalog Spreadsheet

When datalog information is imported into most spreadsheet software, it appears similar to the example below.

Note: *Not all columns are included in this example. Additional Toxic TWA and Toxic STEL display on a normal spreadsheet.*

⚠ Warning: Some compatible software packages have an internal file size limit of and may not load the entire file. Check the software limit.

Table 15. Datalog Spreadsheet Example

Date dd-mm-yy	Day Mon=1	Time hh:mm:ss	Toxic1 ppm	Toxic2 ppm	Toxic3 ppm	LEL %CH4 %LEL	O_2 %	Toxic 1 TWA ppm	Toxic 1 STEL ppm	Status Codes	Serial Number	Unit Config
23-12-05	#4	9:54:25	5	10	35			--	--	33------	S104-000001	
23-12-05	#4	9:54:30	10	15	50			--	--	44------	S104-000001	
23-12-05	#4	9:54:35	5	10	35	10	19.5	--	--	1111----	S104-000001	
23-12-05	#4	9:54:40	10	15	200	20	23.5	--	--	2222----	S104-000001	
23-12-05	#4	9:54:45	0	0	0	24	20.9	--	--	-D-E---D	S104-000001	FCEKNL
23-12-05	#4	9:54:50	0	0	0	24	20.9	0	0	--------	S104-000001	FCEKNL
23-12-05	#4	9:54:55	0	0	0	24	20.9	0	0	--L----L	S104-000001	FCEKNL
23-12-05	#4	9:55:00	0	0	0	24	20.9	0	0	LLH----M	S104-000001	FCEKNL
23-12-05	#4	9:55:05	5	10	35			0	0	LLH----M	S104-000001	
23-12-05	#4	9:55:10	10	15	50			0	0	LLL----M	S104-000001	
23-12-05	#4	9:55:15	5	10	35	10	19.5	0	0	-L-----L	S104-000001	
23-12-05	#4	9:55:20	10	15	200	20	23.5	0	0	--------	S104-000001	
23-12-05	#4	9:55:25	0	0	0	24	20.9	0	0	------B-	S104-000001	FCEKNL
23-12-05	#4	9:55:30	0	0	0	24	20.9	0	0	------B-	S104-000001	FCEKNL

Table 16. Datalog Status Codes

Status Codes					
—	Normal operation	**G**	Backlight is on		
L	Low alarm	**v**	STEL and high alarm (dual alarms)	**1**	Alarm setpoint 1 (low alarm)
H	High alarm	**w**	TWA and STEL alarm (dual alarms)	**2**	Alarm setpoint 2 (high alarm)
T	TWA alarm	**x**	TWA, STEL, and low (triple alarms)	**3**	Alarm setpoint 3 (TWA alarm)
U	TWA and low alarm (dual alarms)	**y**	TWA, STEL, and high (triple alarms)	**4**	Alarm setpoint 4 (STEL alarm)
V	TWA and high alarm (dual alarms)	**O**	Overload / sensor is over-ranged	**D**	Calibration due date (days)
s	STEL alarm	**C**	Calibrating	**E**	Elapsed / last calibration (days)
u	STEL and low alarm (dual alarms)	**F**	Failure - sensor failure	**Z**	Auto zeroing
f	Fresh air delay	**I**	Time set	**t**	testing
Pump Codes					
P	Plugged (blocked) - pump alarm	**F**	Failure / pump failure		
Battery Status Codes					
—	Batteries OK	**B**	Low battery alarm	**C**	Confidence beep is active
Alarm Status Codes					
L	Low alarm	**M**	Multi-gas alarm	**S**	Automatic shutdown
H	High alarm	**C**	Calibration	**F**	Failure / self-test fail
T	TWA alarm	**Q**	Off/quit / manual shutdown	**R**	RTCC / real-time clock failure

Note: *TWA readings greater than 99 are recorded as OL.*

Table 17. Datalog Gas and Correction Factor Sensor Codes

Gas Sensor Codes									
A	No sensor	**B**	H_2S	**C**	H_2S COSH	**D**	CO	**E**	CO COSH
F	SO_2	**G**	PH_3	**H**	NO_2	**I**	HCN	**J**	Cl_2
K	NH_3	**L**	ClO_2	**M**	O_3	**O**	LEL	**P**	PID
Q	IR								
Correction Factor Codes for PID (if applicable)									
A	Acetaldhyde	**B**	Acetone	**C**	Ammonia	**D**	Benzene	**E**	Butadiene
F	Diesel	**G**	Ethanol	**H**	Ethylene	**I**	Gasoline	**J**	Hexane
K	Isobtyln	**L**	JP8	**M**	Kerosene	**N**	MEK	**O**	Naptha
P	Styrene	**Q**	Toluene	**R**	Turpentine	**S**	Vinyl_Cl	**T**	Xylene
U	Custom								
Correction Factor Codes for LEL									
A	Acetone	**B**	Benzene	**C**	Butane	**D**	Cyclohexane	**E**	Ethanol
F	Ethyl_Ace	**G**	Gasoline	**H**	Heptane	**I**	Hexane	**J**	Hydrogen
K	Isobutylene	**L**	Isopropanol	**M**	MEK	**N**	Methane	**O**	Methanol
P	Octane	**Q**	Pentane	**R**	Propane	**S**	Toluene	**T**	Turpentine
U	Custom								
LEL Unit Codes									
V	LEL in % by Vol CH_4			**L**	LEL in % LEL				

Maintenance

To maintain the detector in good operating condition, perform the following basic maintenance as required.

- Calibrate, bump test, and inspect the detector at regular intervals.
- Maintain an operations log of all maintenance, calibrations, bump tests, and alarm events.
- Clean the exterior with a soft damp cloth. Do not use solvents, soaps, or polishes.
- Do not immerse the detector in liquids.

Replacing/Charging the Batteries

⚠ Warning

To avoid personal injury, adhere to the following:

⇒ **Replace the batteries immediately when the detector emits a low battery alarm.**

⇒ **Use only batteries that are recommended by BW Technologies to prevent personal injury and/or property damage.**

⇒ **Use only approved batteries, properly installed in the detector case. Refer to Specifications for approved batteries.**

⇒ **Charge batteries using only a recommended BW charger. Do not use any other charger. Failure to adhere to this precaution can lead to fire and/or explosion.**

⇒ **Both the rechargeable battery pack and the alkaline battery pack are hot-swappable, but the alkaline battery cells inside the pack can only be replaced in a non-hazardous location.**

Note

To preserve battery life, deactivate the detector when not in use.

To charge the rechargeable battery pack, refer to the *GasAlertMicro 5 Battery Charger User Manual*.

To replace the alkaline batteries, refer to Table 18, Figure 7, and the following procedures.

Table 18. Replacing the Batteries

Item	Description
1	Detector
2	Latch
3	Battery pack
4	Battery tray
5	Captive screws (2)
6	Alkaline batteries (3)
7	Battery shell

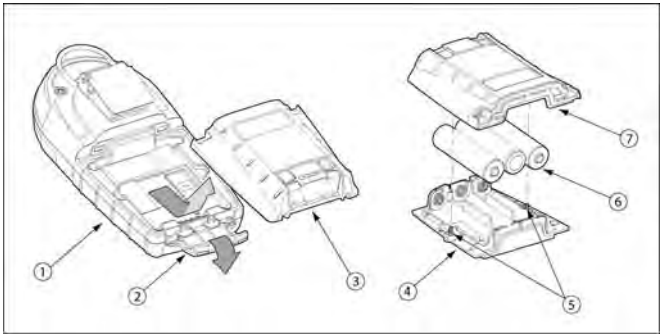


Figure 7. Replacing the Batteries

1. Open the latch on the bottom of the detector.
2. Remove the battery pack by lifting the bottom of the pack away from the detector.
3. Unscrew the two captive screws on the battery pack and open the pack.
4. Replace the three alkaline batteries and screw the battery pack back together.
5. Reinsert the battery pack and secure the latch.

Replacing a Sensor or Sensor Filter

⚠ Warning

To avoid personal injury, use only sensors specifically designed for the detector. Refer to Replacement Parts and Accessories.

Each sensor has a high degree of resistance to common vapors and gases. To clear a sensor, move the detector to a clean environment and wait 10 to 30 minutes.

Do not expose a sensor to vapors of inorganic solvents such as paint fumes or organic solvents. Refer to Troubleshooting for reference to problems caused by a sensor that requires calibration or replacement.

To replace a sensor or sensor filter, refer to Figure 8, Table 19, and the following procedures.

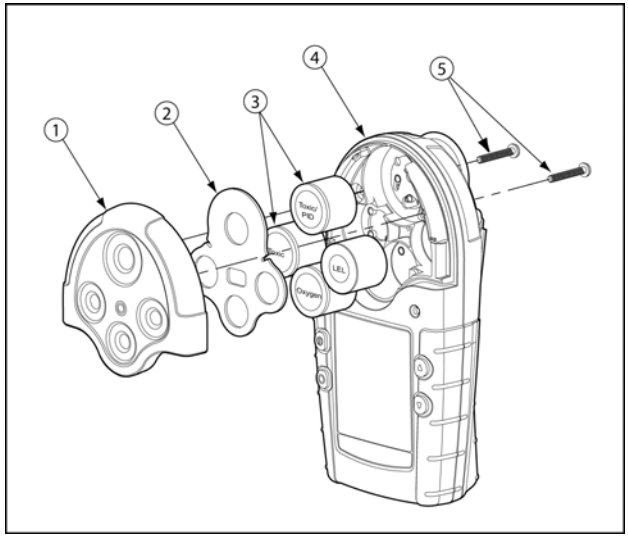


Figure 8. Replacing a Sensor or Sensor Filter

Note

Detectors that are configured for 1, 2, 3, or 4 gases may contain a dummy sensor in one of the four sensor locations.

Table 19. Replacing a Sensor or Sensor Filter

Item	Description
1	Sensor cover
2	Sensor filter
3	Sensors
4	Detector
5	Machine screws (2)

1. If required, deactivate the detector.
2. Remove the two machine screws on the rear shell and then remove the sensor cover or optional pump module.
3. Remove the sensor filter and/or the sensor(s). Gently rocking the sensor back and forth may help free a tightly held sensor.
4. Insert the new filter and/or sensor. Ensure the sensor posts are aligned correctly.
5. Re-assemble the detector.
6. If the sensor is changed (eg. SO_2 to an H_2S), the detector must be reconfigured. Refer to the Sensors in the Tech Mode option.
7. Calibrate the detector after changing any sensor(s). Refer to Calibration and Setting Alarm Setpoints.

Photoionization Detector (PID)

Clean or Replace the Lamp

The PID lamp must be cleaned on a regular basis. Use only the cleaning kit that is supplied by BW Technologies.

To clean the PID lamp, refer to the illustrations and procedures that are provided with the *PID Lamp Cleaning Kit*. To order the kit, refer to Replacement Parts and Accessories.

Note

To ensure proper maintenance and continued accurate readings from the sensor, use only the PID Lamp Cleaning Kit that is provided by BW Technologies.

Table 20. Parts of the PID sensor

Item	Description
1	Sensor cover
2	Electrode stack
3	Diffusion barrier
4	Lamp
5	PID sensor

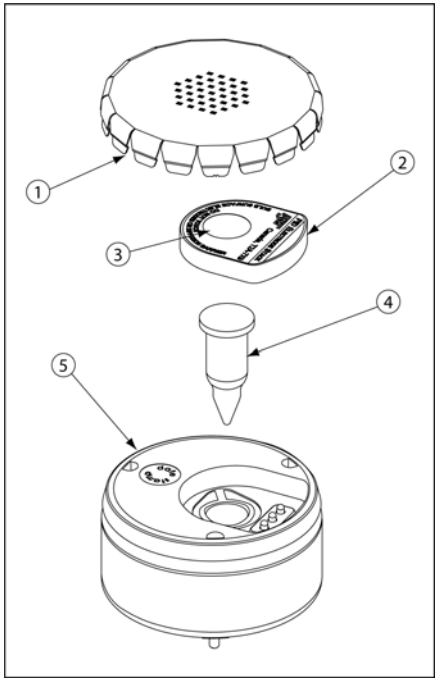


Figure 9. Parts of the PID

Replace the Lamp

Replace the lamp when it falls below the acceptable level. Possible indicators that the lamp requires replacement are as follows:

- The detector will not calibrate.
- The start-up self-test fails.
- The ppm levels are incorrect.

To replace the lamp, refer to the illustrations and procedures in the *PID Lamp Cleaning Kit*.

If required, contact BW Technologies for more information.

Replace the Electrode Stack

Replace the electrode stack when it is contaminated. To replace the electrode stack, refer to Table 20, Figure 9, and the following procedures.

1. Remove the sensor cover.
2. Remove the old electrode stack.
3. Insert the new electrode stack.

Note

Ensure your fingers do not make contact with the diffusion barrier or the electrodes on the underside of the stack.

4. Replace the sensor cover.

Troubleshooting

If a problem occurs, refer to the solutions provided in Table 21.

If the problem persists, contact BW Technologies.

Table 21. Troubleshooting Tips

Problem	Possible Cause	Solution
The detector does activate.	No batteries	Refer to Replacing/Charging the Batteries.
	Depleted batteries	Refer to Replacing/Charging the Batteries.
	Damaged or defective detector	Contact BW Technologies.
The detector immediately enters alarm mode when activated.	Sensor needs to stabilize	Used sensor: wait 60 seconds New sensor: wait 5 minutes
	Low battery alarm	Refer to Replacing/Charging the Batteries.
	Sensor alarm	Refer to Replacing a Sensor or Sensor Filter.
	Pump alarm	If the sampling hose is attached, determine if it is obstructed. If not, clean or replace the pump filter. If pump alarm persists, contact BW Technologies.
The activation self-test fails.	General fault	Ensure that the sensors and battery pack are installed correctly and then restart the detector. If fault persists, record the error message and contact BW Technologies.

Table 21. Troubleshooting Tips (cont.)

Problem	Possible Cause	Solution
	The MMC/SD is not inserted	Insert the MMC/SD card. Refer to Inserting the MMC/SD Card.
	The MMC/SD card that is inserted in the detector has a storage size that is not supported by the detector	Insert an Infineon MMC/SD card that is • 32 MB only
	The detector has lost communication with the MMC/SD card	Attempt the following solutions: • Retry communication • Insert a different Infineon MMC 32 MB • Clear MMC in windows and reinsert into the detector. • Contact BW Technologies.

Table 21. Troubleshooting Tips (cont.)

Problem	Possible Casue	Solution
The detector displays a clock error message using last recorded time.	General fault	Reactivate the detector. If the message does not display, reset the clock in user options. If the error message still displays, contact BW Technologies.
Detector does not display normal ambient gas reading after activation self-test.	Sensor not stabilized	Used sensor: wait 60 seconds New sensor: wait 5 minutes
	Detector requires calibration	Refer to Calibration and Setting Alarm Setpoints.
	Target gas is present	Detector is operating properly. Use caution in suspect areas.
Detector does not respond to pushbuttons.	Batteries are depleted	Refer to Replacing/Charging the Batteries.
	Detector is performing operations that do not require user input.	Pushbutton function restored automatically when the operation ends.
Detector does not accurately measure gas.	Detector requires calibration	Refer to Calibration and Setting Alarm Setpoints.
	Detector is colder/hotter than ambient gas	Allow the detector to acquire ambient temperature before using.
	Sensor filter is blocked	Clean the sensor filter. Refer to Replacing a Sensor or Sensor Filter.

Table 21. Troubleshooting Tips (cont.)

Problem	Possible Cause	Solution
Detector does not enter alarm mode.	Alarm setpoint(s) are set incorrectly	Reset alarm setpoints. Refer to Calibration and Setting Alarm Setpoints.
	Alarm setpoint(s) set to zero	Reset alarm setpoints. Refer to Calibration and Setting Alarm Setpoints.
	Detector requires calibration	Calibrate the detector. Refer to Calibration and Setting Alarm Setpoints.
Detector intermittently enters alarm without any apparent reason.	Ambient gas levels are near alarm setpoint or the sensor is exposed to a puff of the target gas	Detector is operating normally. Use caution in suspect areas. Check MAX gas exposure reading.
	Alarms set incorrectly	Reset alarm setpoints. Refer to Calibration and Setting Alarm Setpoints.
	Missing or faulty sensor	Refer to Replacing a Sensor or Sensor Filter.
Detector automatically deactivates.	Automatic shutdown activated because of weak batteries	Refer to Replacing/Charging the Batteries.
Clock icon is flashing.	The clock has failed	Contact BW Technologies.
	There is communication failure	Contact BW Technologies.

Replacement Parts and Accessories

⚠ Warning

To avoid personal injury and/or damage to the detector, use only the specified replacement parts.

To order parts or accessories listed in Table 22, contact BW Technologies.

Table 22. Replacement Parts and Accessories

Model No.	Description	Qty
S4-W04	Combustible sensor	1
S4-W04-SF	Combustible sensor (with silicone filter)	1
SR-X10	O_2 sensor	1
PS-RM04	CO sensor	1
PS-RH04S	H_2S sensor	1
SR-P04	PH_3 sensor	1
PS-RS04	SO_2 sensor	1
PS-RC10	Cl_2 sensor	1
SR-A04	NH_3 sensor	1
PS-RD04	NO_2 sensor	1
PS-RZ10	HCN sensor	1
SR-V04	ClO_2 sensor	1
SR-G04	O_3 sensor	1
D4-RHM04	TwinTox CO/H_2S sensor	1
SR-Q07	PID sensor	1
RL-PID10.6	Lamp for PID sensor	1
M5PID-ES-1	Electrode stack for PID sensor	2
M5PID-CLN-K1	Cleaning kit for PID sensor lamp	1
M5-SS	Sensor filters (quad) kit of 2	2
CG-Q58-4	Quad calibration gas, CH_4-2.5%, O_2-18.0%, H_2S-25 ppm, CO-100 ppm, bal. N_2 (58 l)	1
CG-Q34-4	Quad calibration gas, CH_4-2.5%, O_2-18.0%, H_2S-25 ppm, CO-100 ppm, bal. N_2 (34 l)	1
CG-T34	Two gas calibration cylinder, 50% LEL (CH_4-2.5%) O_2-20.9%, bal. N_2 (34 l)	1
CG2-S-25-58	Calibration gas, SO_2 25 ppm (58 l)	1
CG-BUMP-S25	SO_2 bump test gas	1
CG-BUMP1	Bump alarm gas aerosol (CH_4-2.5%, O_2-10%, H_2S-40 ppm, CO-200 ppm)	1
REG-0.5	Regulator (0.5 l/min)	1

Model No.	Description	Qty
G0042-H25	Calibration gas, H_2S 25 ppm (58 l)	1
CG2-M-200-103	Calibration gas, CO 200 ppm (103 l)	1
CG2-S-25-58	Calibration gas, SO_2 25 ppm (58 l)	1
CG2-C-5-58	Calibration gas, Cl_2 5 ppm (58 l)	1
CG2-Z-10-58	Calibration gas, HCN 10 ppm (58 l)	1
CG2-D-10-58	Calibration gas, NO_2 10 ppm (58 l)	1
CG2-P-1-58	Calibration gas, PH_3 1 ppm (58 l)	1
CK-Q34-4	Quad calibration kit with regulator, quad gas cylinder (CG-Q34-4), hose and carrying case	1
CK-Q58-4	Quad calibration kit with regulator, quad gas cylinder (CG-Q58-4), hose and carrying case	1
CR-MMC-USB1	MMC USB reader (USB port) with software for user-downloadable datalogger	1
M5-MMC32	32 MB MultiMediaCard	1
M5-BAT01	Rechargeable battery pack	1

Model No.	Description	Qty
M5-BAT02	Alkaline battery pack	1
M5-CO1*	GasAlertMicro 5 battery charger	1
M5-CO1-BAT01*	GasAlertMicro 5 battery charger and battery pack kit	1
GA-V-CHRG4	Vehicle GasAlertMicro 5 battery charger	1
M5-PUMP	Motorized Pump Module Kit	1
GA-PROB1-1	Sample pump with 1 ft./0.3 m probe tubing	1
M5-TC-1	Calibration cap and hose	1
GA-AG-2	Alligator clip (stainless steel)	1
GA-CH-2	Chest harness	1
GA-ES-1	Extension strap	1
GA-ARM-1	Arm band	1
GA-HM5	Belt holster	1

**Add suffix (-UK) for United Kingdom mains plug, (-EU) for European mains plug, (-AU) for Australian mains plug.*

Specifications

Instrument dimensions: 14.5 x 7.4 x 3.8 cm (5.7 x 2.9 x 1.5 in.)

Weight: 370 g (13.1 oz.)

Operating and storage conditions
Temperature:
VOC: -10°C to +40°C (-14°F to +104°F)
Other gases: -20°C to +50°C (-4°F to +122°F)
Humidity:
O_2: 0% to 99% relative humidity (non-condensing)
VOC: 0% to 95% relative humidity (non-condensing)
Combustibles: 5% to 95% relative humidity (non-condensing)
Cl_2: 10% to 95% relative humidity (non-condensing)
HCN, ClO_2: 15% to 95% relative humidity (non-condensing)
Other gases: 15% to 90% relative humidity (non-condensing)
Pressure:
95 to 110 kPa

Alarm setpoints: May vary by region and are user-settable.

Detection range:
O_2: 0 – 30.0% vol. (0.1% vol. increments)
CO: 0 – 999 ppm (1 ppm increments)
CO (TwinTox sensor): 0 – 500 ppm (1 ppm increments)
H_2S: 0 – 500 ppm (1 ppm increments)
H_2S (TwinTox sensor): 0 – 500 ppm (1 ppm increments)
Combustibles: 0 – 100% LEL (1% LEL increments) or 0 – 5.0% v/v methane
PH_3: 0 – 5.0 ppm (0.1 ppm increments)
SO_2: 0 – 150 ppm (1 ppm increments)
Cl_2: 0 – 50.0 ppm (0.1 ppm increments)
NH_3: 0 – 100 ppm (1 ppm increments)
NO_2: 0 – 99.9 ppm (0.1 ppm increments)
HCN: 0 – 30.0 ppm (0.1 ppm increments)
ClO_2: 0 – 1.00 ppm (0.01 ppm increments)
O_3: 0 – 1.00 ppm (0.01 ppm increments)
VOC: 0 – 1000 ppm (1.0 ppm increments)

Sensor type:
H_2S/CO: Twin plug-in electrochemical cell
Combustibles: Plug-in catalytic bead
VOC: Photoionization detector (PID)
Other gases: Single plug-in electrochemical cell

O_2 measuring principle: Capillary controlled concentration sensor

Alarm conditions: TWA alarm, STEL alarm, low alarm, high alarm, multi-gas alarm, over range alarm, sensor alarm, pump alarm, MMC fail alarm, low battery alarm, confidence beep, automatic shutdown alarm

Audible alarm: 95 dB at 1 ft. (0.3 m) variable pulsed dual beepers

Visual alarm: Dual red light-emitting diodes (LED)

Display: Alphanumeric liquid crystal display (LCD)

Backlight: Automatically activates whenever there is insufficient light to view the LCD (if enabled) and during alarm conditions.

Self-test: Initiated upon activation

Calibration: Automatic zero and automatic span

Oxygen sensor: Automatic span upon activation (selectable)

User field options: Confidence beep, latching low and high alarms, pass code protection, enable/disable safe display mode, enable/disable fast pump, combustible sensor measurement, sensor disable, TWA and STEL, language selection, enable/disable automatic oxygen calibration, set span concentration values, set STEL calculation period, set TWA method, gas measurement resolution, enable/disable automatic backlight, adjust clock calendar, and set logging rate (datalogger models only).

Datalogger units: Use only Infineon 32 MB MMCs

Battery operating time:

Toxic, O_2, and LEL sensors: 20 hours (three alkaline cells or one rechargeable battery pack)
Toxic, O2, LEL, and PID sensors: 10 hours (three alkaline cells or one rechargeable battery pack)

Approved batteries: Approved batteries for product (standards IEC 60279-11, EN50020, UL913, C22.2 No. 157)

Alkaline:		**Temperature Code**
Duracell MN1500	-20°C ≤Ta ≤ +50°C	T3C (139.8°C)
	-20°C ≤Ta ≤ +40°C	T4 (129.8°C)
Energizer E91	-20°C ≤Ta ≤ +50°C	T3B (163°C)
	-20°C ≤Ta ≤ +40°C	T3C (153°C)
NiMH rechargeable:		
M5-BAT01	-20°C ≤Ta ≤ +50°C	T4

Battery charger: GasAlertMicro 5 battery charger

First-time charge: 4 hours per battery pack

Normal charge: 3-4 hours per battery pack

Warranty: 2 years including sensors
(1 year for NH_3 sensor and PID lamp)

Approvals
Approved by CSA to both U.S. and Canadian Standards

Approved: Class I, Division 1, Group A, B, C, and D;
Class I, Zone 0, Group IIC

Standards: CAN/CSA C22.2 No. 157 and C22.2 152
ANSI/UL – 913 and ANSI/ISA – S12.13 Part 1

ATEX: CE 0539 Ⓔx II 1 G EEx ia IIC
KEMA 05ATEX 1096X

IECEx: Ex ia IIC

ABS Type Approved: VA-348169-X

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules and ICES-003 Canadian EMI requirements. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

General Specifications for Datalogger Units

Media type: MultiMediaCard (MMC)

Size: 32 MB (Infineon MMC only)

Storage: 500,000 lines of data available; 4.4 months at 5 second intervals (based on a normal work week)

Memory type: Wrap-around memory ensures most recent data is always saved

Sample rate: One reading every 5 seconds (standard)

Data recorded: All sensor readings, all alarm conditions, calibrations, event flags, battery status, pump status, sensor status, confidence beep activation, and detector status along with the time and date for each reading and unit serial number

MMC/SD test: Automatically on activation

GasAlertMicro 5 and GasLaertMIcro 5 PID with User Downloadable Datalogger

Operation: Requires no user intervention (automatic)

Indicators: Icon advises datalogger is operating normally, MMC/SD missing/malfunction advise

Compatible with: Desktop PC computer or laptop

Operating system: Windows 95 or higher; Macintosh OS 8.6 or higher

Download via: MMC/SD card reader.

Software required: Spreadsheet or database compatible with comma-separated-value (CSV) text files (Excel, Access, Quattro, etc.)

Card alarm: Card fail or missing

Support:
Fleet Manager: Fleet Manager is an Access software add-in that enhances the abilities of Microsoft® Access when handling GasAlertMicro 5 user downloadable datalogger data files.

Appendix A PID Correction Factor (CF) Library

Table 23. PID Corrections Factor (CF) Library

Gas #	Gas Type	LCD Gas Type Abrreviation	Correction Factor Value (CF values subject to change)
1	No PID correction factor	N/A	N/A
2	Acetaldehyde	Acetdhd	d'4.6'
3	Acetone	Acetone	d'1.2'
4	Ammonia	Ammonia	d'10.6'
5	Benzene	Benzene	d'0.5'
6	Butadiene	Butadien	d'0.9'
7	Diesel	Diesel	d'0.9'
8	Ethanol	Ethanol	d'13.3'
9	Ethylene	Ethylene	d'9.1'
10	Gasoline	Gasoline	d'0.7'
11	Hexane	Hexane	d'4.6'
12	Isobtyln	Isobtyln	d'1.0'
13	JP8	JP-8	d'0.5'
14	Kerosene	Kerosene	d'1.1'
15	MEK	MEK	d'0.9'

Table 23. PID Correction Factors (CF) Library (cont.)

Gas #	Gas Type	LCD Gas Type Abrreviation	Correction Factor Value (CF values subject to change)
16	Naptha	Naptha	d'1.0'
17	Styrene	Styrene	d'0.5'
18	Toluene	Toluene	d'0.5'
19	Turpentine	Turpentine	d'0.5'
20	Vinyl Chloride	Vinyl Chloride	d'2.2'
21	Xylene	Xylene	d'0.5'
22	Custom	Custom	0.1 to 15.0

D5615/1 (English)
iERP: 119085

B9 Field Screening with RKI Eagle Portable Multi-Gas Detector

B9.a. SOP for Field Operating Procedures for the RIK Eagle 2 Portable Multi-Gas Detector

ARCADIS
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Field Operating Procedures for the RIK Eagle 2 Portable Multi-Gas Detector

Rev. #: 1

Rev Date: July 24, 2012

Approval Signatures

Prepared by: _____ Date: _____
Kim Egler, Project Chemist

Reviewed by: _____ Date: _____
Chris Lutes, Principal Scientist

I. Scope and Application

Field screening with the RKI Eagle 2 Portable Multi-Gas Detector can be used for simultaneous detection of one to six gases. The standard configuration includes four sensors for combustible gas (%LEL, ppm, and %volume), oxygen, carbon monoxide, and hydrogen sulfide. A TC (Thermal Conductivity) sensor is also available for % Vol. hydrogen or % Vol. methane. It also is capable of data logging functions and has over-range alarms.

It is anticipated that this monitor may be used to analyze the following gases in the field: oxygen (% volume), hydrogen sulfide (ppm), ammonia (ppm), hydrogen cyanide (ppm), and phosphine (ppm). With the TC sensors, highly combustible gases like hydrogen, methane, and acetylene can also be analyzed. This instrument can be used for surveys of potential sources, personal exposure monitoring or area surveys.

II. Personnel Qualifications

Personnel performing this method should be familiar with the basic principles of quantiative analytical chemistry (such as calibration) and familiar with the particular operation of the instrument to be used.

III. Equipment List

The following materials, as required, shall be available while performing field Screening with the RIK Eagle 2:

- personal protective equipment (PPE), as required by the site Health and Safety Plan (HASP)
- RIK Eagle 2 and operating manual (available online, see references)
- extra batteries and battery charger
- 5-foot polyurethane sample hose (standard with monitor)
- 10-inch hydrophobic probe (standard with monitor)
- shoulder strap
- calibration canisters

IV. Cautions

Exposure to high concentrations of combustible gas may adversely affect the performance of the sensor.

Some gases such as silicone vapors, chlorinated hydrocarbons, and sulfur compounds can contaminate the detection elements inside the combustible sensor damaging the sensor and result in reduced response to combustible gas. Make every effort to avoid these gases. The catalytic combustible sensor has an integral hydrogen sulfide scrubber for protection from hydrogen sulfide exposure resulting from normal use, but you should avoid exposure to high levels of hydrogen sulfide and other sulfur compounds.

V. Health and Safety Considerations

The RIK EAGLE 2 detects oxygen deficiency, elevated levels of oxygen, combustible gases, carbon monoxide, and hydrogen sulfide, all of which can be dangerous or life threatening. When using the EAGLE 2, you must follow the instructions and warnings in the Operator's Manual to assure proper and safe operation of the unit and to minimize the risk of personal injury. Be sure to maintain and periodically calibrate the EAGLE 2 as described in the manual and this SOP. Follow all procedures detailed in the site Health and Safety Plan (HASP) for monitoring at each location.

Any rapid increase in the combustible gas reading on the catalytic combustible channel followed by a declining or erratic reading may indicate a gas concentration above the LEL which may be hazardous.

Since the RIK Eagle 2 cannot detect all of the chemicals that may be present at a sample location, a zero reading on either instrument does not necessarily signify the absence of air contaminants.

VI. Procedure (*Note these procedures were written particular to one specific instrument model, therefore please also refer to your owner's manual. However the general principles – such as always measuring both a zero and span gas at the beginning and end of the analytical day, or after suspected exposure to high concentrations of combustible gas can be applied to all comparable instruments.)*

RIK Eagle 2 Calibration

Operation, maintenance, and calibration shall be performed in accordance with the manufacturer's instructions and entered into the project logbook. Prior to each day's sampling, a zero, span gas and an additional standard ("bump test") will be

conducted to confirm linearity over the range of interest. The combustible sensor will be checked with a known concentration of calibration gas after any known exposure to catalyst contaminants/poisons (sulfur compounds, silicon vapors, halogenated compounds, etc). If an alarm occurs due to high concentration of combustible gases, recalibration will be performed, or if needed, the sensor replaced.

1. Don PPE, as required by the HASP.

2. Connect the sample hose and probe to the Eagle 2's quick connect inlet fitting. Press and briefly hold down the POWER ENTER RESET button. Release when you hear a beep.

3. The instrument goes through its warm-up sequence and shows screens for battery voltage, active gases, low alarm, high alarm, STEL and TWA, calibration reminder (if CAL REMINDER is turned on), date and time, and sensor failures. It then goes into measuring mode. Verify that there is sufficient battery life for the intended monitoring period, and recharge if necessary.

To calibrate the %LEL, oxygen, carbon monoxide (CO), and hydrogen sulfide (H_2S) sensors at the same time, automatically, with no need for a zero-oxygen source, you can use the auto calibration feature with a 4-gas cylinder. If the H_2S channel is not active, then a 3-gas cylinder may be used for auto calibration. It is also possible to calibrate one channel at a time using single calibration. Since multiple analytes will be monitored at the same time, this SOP will address the auto calibration procedure.

Follow the auto calibration procedure as detailed in the Operator's Manual starting on page 56. The relevant manual pages have been attached at the end of this SOP for convenience; the entire manual is also available online (see references). Details on the datalogger, maintenance and troubleshooting, and TC sensors, can be found on pages 53, 68, and 182, respectively.

- Verify that the calibration gas you are using matches the span concentration value(s) in the detector.

- The detector should be allowed to stabilize for 1 minute, after activation, prior to calibration, or a bump test.

1. Set the fresh air reading by choosing the "AIR ADJUST" option. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.

2. Perform a span adjustment in auto calibration. The gas concentrations displayed in the Calibration Gas Values Screen must match the gas concentrations listed

on the 4-gas calibration cylinder. Follow the instructions in the Operator's Manual if one or more concentrations do not match.

3. If all concentrations match, connect the tubing from the demand flow regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for one minute. Press and release the POWER ENTER RESET button to set the span adjustment for each channel to the programmed values.

   If any of the sensors cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and lists the sensor(s) that failed to calibrate. Attempt the calibration again. If the calibration fails again, investigate the cause (see "Troubleshooting" section of the manual).

At the beginning and end of each daily use session of the instrument, introduce into the instrument after the calibration process is complete and the instrument "thinks" it is observing a sample three gasses:

- Zero gas
- Span gas of known concentrations of each analyte
- Midpoint gas of known concentrations of each analyte

Record the known concentration of the standard (usually written on the cylinder) and the observed concentration.

Compare the results of the span and midpoint gasses. If the result is outside of the range of 75-125% of the known true value, recalibrate the instrument and retest. If that is not successful immediately contact the project QA manager or project manager for advice.

VII. Waste Management

Do not dispose canisters of compressed gas, if there is still compressed gas in the canister. Return the canister to the manufacturer for proper disposal.

VIII. Data Recording and Management

RKI Eagle 2 monitors will be operated in a survey mode with time-stamped datalogging for those gasses amenable to field instrument monitoring (all analytes except for hydrofluoric acid; hydrogen, methane and acetylene will be monitored for LEL as described below). GPS data will also be recorded with a synchronized time

stamp. Additional field information will be recorded in the field notebook at the time of measurement with notation of date, time, location, depth (if applicable), and item monitored. If a data memory is available, readings will be downloaded from the unit upon access to a computer with software to retrieve the data.

IX. Quality Assurance

After each use, the readout unit should be wiped down with a clean cloth or paper towel.

Verify that all calibration gases are within their expiration date.

X. References

RKI Instruments. "Eagle 2 Operator's Manual." Revision H. Released 3/30/12 and available at http://www.rkiinstruments.com/pdf/71-0154RK.pdf (accessed 7/24/12).

RKI Instruments. "Quick Reference Guide for Model Eagle 2." Revision P1. Available at http://www.rkiinstruments.com/pdf/Eagle2_quick_reference.pdf (accessed 7/24/12).

Calibration Supplies and Equipment

To calibrate the EAGLE 2, you will need:

- Known calibrating samples of the gases being detected. The combustible and toxic gas samples should have concentrations in approximately the middle of the detection range. An oxygen-free source, such as 100% nitrogen is recommended for setting the oxygen zero.

CAUTION: *When using auto calibration with the standard 4-gas EAGLE 2, although the EAGLE 2 can be calibrated with an oxygen concentration of up to 19.5%, RKI Instruments, Inc. recommends that the multi-gas cylinder have an oxygen concentration in the range of 10% - 16% oxygen.*

- A demand-flow regulator to provide adequate sample gas flow
- Non-absorbent tubing

WARNING: ***If you are using a calibration kit that includes a gas bag and a fixed flow regulator or dispensing valve, do not apply gas directly to the EAGLE 2 with the regulator or dispensing valve or damage to the pump will result. See "Appendix A: Calibrating with a Sample Bag" on page 83 for instructions to properly use a gas bag kit.***

To calibrate the %LEL, oxygen, CO, and H_2S sensors at the same time, automatically, with no need for a zero-oxygen source, you can use the auto calibration feature with a 4-gas cylinder. If the H_2S channel is not active, then a 3-gas cylinder may be used for auto calibration. This chapter includes instructions for auto calibration with a demand-flow regulator and a 4-gas cylinder. This chapter also includes instructions for calibrating one channel at a time using single calibration.

Entering Calibration Mode

To enter Calibration Mode, do the following:

1. Find a fresh-air environment. This is an environment free of toxic or combustible gases and of normal oxygen content (20.9%).
2. While in Measuring Mode, press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both buttons.

3. If the unit prompts you for the password, enter it by using the AIR ▲ YES and RANGE ▼ SHIFT buttons to select each password number and then pressing and releasing POWER ENTER RESET to enter the number and move on to the next one.
4. The Calibration Mode Screen displays with the cursor next to **AUTO CALIBRATION**.

```
CALIBRATION MODE

> AUTO CALIBRATION
  SINGLE CALIBRATION
  PERFORM AIR ADJUST
  NORMAL OPERATION
```

NOTE: The following screens illustrate a four-gas EAGLE 2 for detection of CH_4 (%LEL using catalytic sensor), oxygen, H_2S, and CO. Your EAGLE 2 may display slightly different screens.

Calibrating Using the Auto Calibration Method

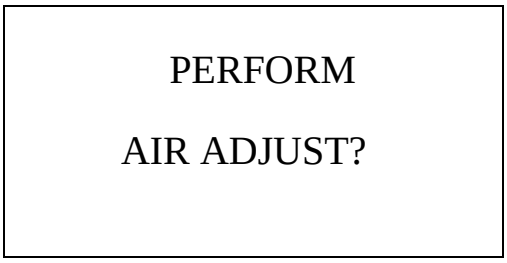
This method allows you to calibrate the CH_4 (%LEL sensor), oxygen, H_2S, and CO sensors simultaneously. It is designed for use with the RKI 4-gas calibration cylinder and is the quickest and easiest method to calibrate the EAGLE 2.

Setting the Fresh Air Reading

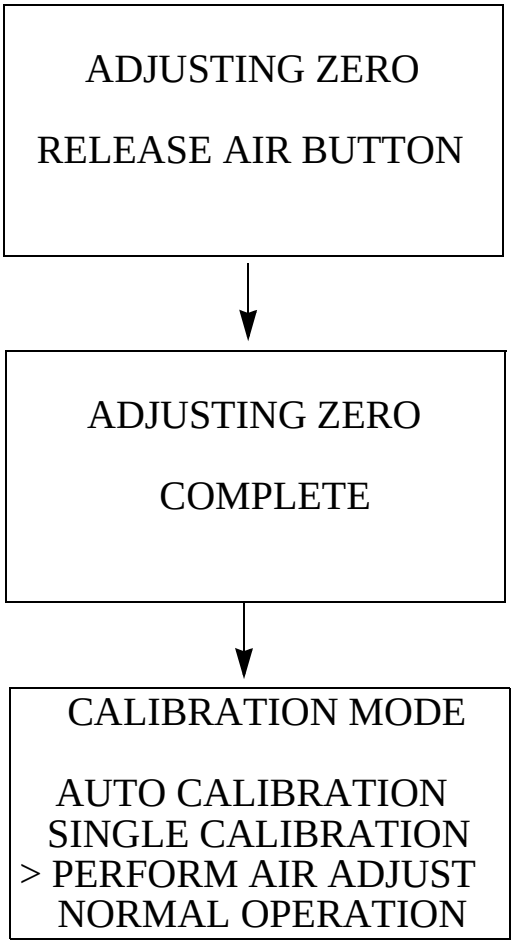
1. While in the Calibration Mode Screen, move the cursor to the **PERFORM AIR ADJUST** menu item by using the RANGE ▼ SHIFT button.

```
CALIBRATION MODE

  AUTO CALIBRATION
  SINGLE CALIBRATION
> PERFORM AIR ADJUST
  NORMAL OPERATION
```

2. Press and release the POWER ENTER RESET button. The following screen appears.

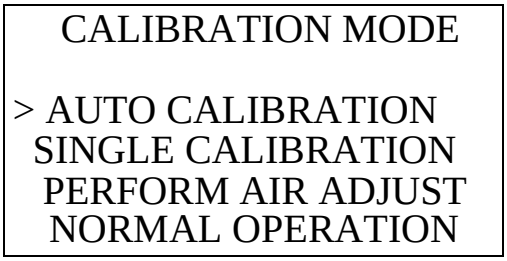


3. Press and release the AIR ▲ YES button to continue.
   If you do not want to continue, press the DISPLAY ADJUST NO button and the unit will return to the Calibration Mode Screen.
4. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.

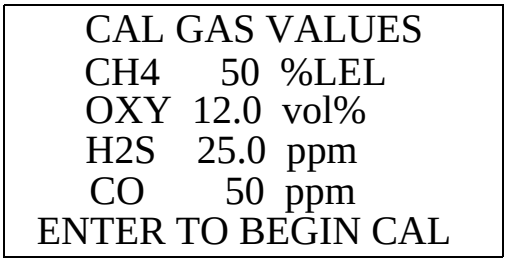


Performing a Span Adjustment in Auto Calibration

1. Install the demand flow regulator onto the calibration cylinder.
2. Connect the sample tubing to the demand flow regulator.
3. Install the probe on the EAGLE 2 inlet fitting. Make sure the probe is complete with internal O-ring and membrane and that the two halves of the probe are tightened firmly together to avoid leaks that can affect the calibration. See Figure 20, “Replacing the Hydrophobic Filter Disk & O-ring” on page 73 for an illustration of the internal parts of the probe.
4. Move the cursor next to the **AUTO CALIBRATION** menu item by using the AIR ▲ YES button.



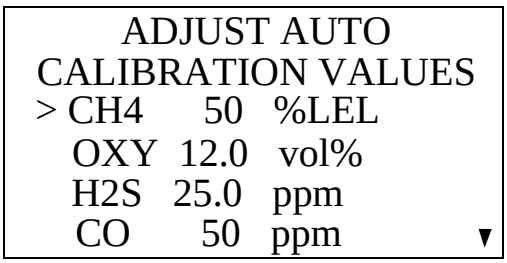
5. Press and release the POWER ENTER RESET button to display the Calibration Gas Values Screen.



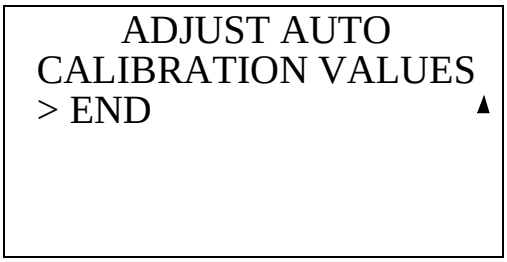
The gas concentrations displayed in the Calibration Gas Values Screen must match the gas concentrations listed on the 4-gas calibration cylinder.
If *all* concentrations match, go to Step 16.
If *one or more* concentrations *do not* match, continue with Step 6.
If you do not want to continue with the calibration, press and release the DISPLAY ADJUST NO button to return to the Calibration Mode Screen.

NOTE: The RKI 4-gas cylinder typically contains 12% O_2 by volume. When using the auto calibration method, be sure to set the “OXY” auto calibration value to agree with the concentration listed on the cylinder’s label, not zero.

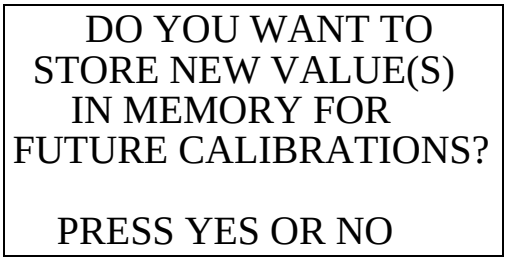
6. To adjust the values on the screen, press and hold the RANGE ▼SHIFT button, then press the DISPLAY ADJUST NO button and release both. The following screen appears with the cursor next to **CH4**.



7. Place the cursor next to the channel whose gas value you want to change using the AIR ▲ YES and RANGE ▼SHIFT buttons.
8. Press and release the POWER ENTER RESET button to select the channel. The calibration gas value begins to flash.
9. Use the AIR ▲ YES and RANGE ▼SHIFT buttons to adjust the calibration gas setting to the desired value.
10. Press and release the POWER ENTER RESET button to save the change. The calibration gas value stops flashing.
11. Repeat Step 7 through Step 10 for any other channels that need to be changed.
12. When you are done adjusting the calibration gas values, move the cursor down past the bottom of the screen next to **END**.



13. Press and release the POWER ENTER RESET button. The following screen appears.

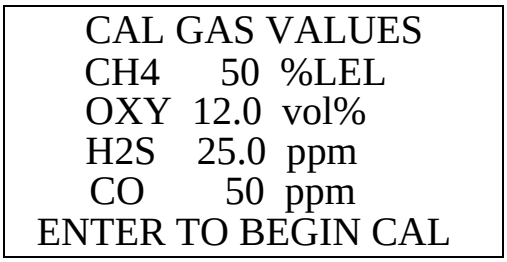


14. If you select YES by pressing and releasing the AIR ▲ YES button, the changes that you made will be saved in the EAGLE 2's memory as the

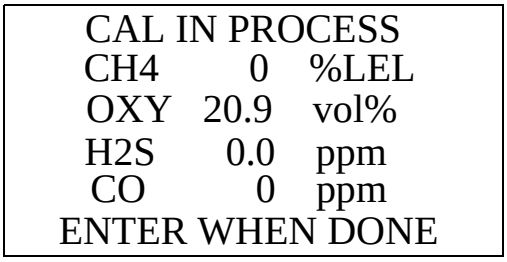
new auto calibration gas values.

If you select NO by pressing and releasing the DISPLAY ADJUST NO button, the changes you made will be used for any calibrations performed during the current operating session only. The EAGLE 2 will delete the changes when the unit is turned off and will load the previous set of auto calibration values when it is turned on again.

15. When you make your selection and press the desired button, the unit returns to the Calibration Gas Values Screen.



16. Press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen with **CAL IN PROCESS** flashing.

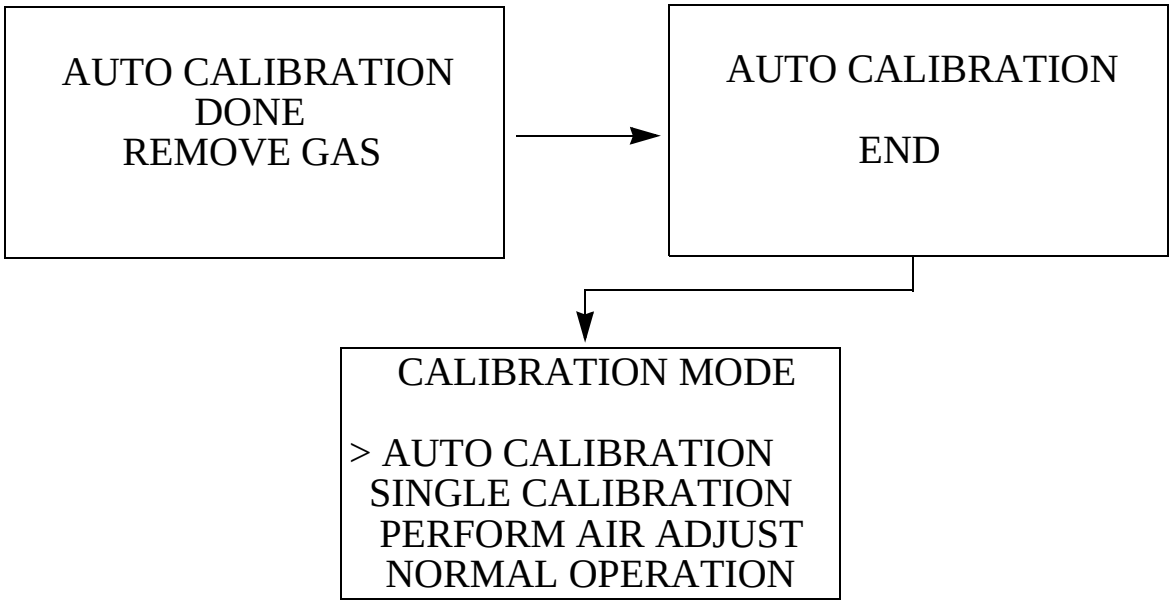


If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the Cal Gas Values Screen.

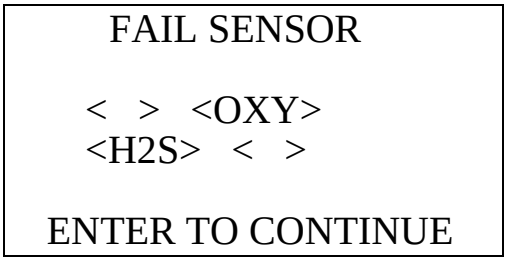
If you do want to continue with the calibration, proceed to the next step.

17. Connect the tubing from the demand flow regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for one minute.
18. Press and release the POWER ENTER RESET button to set the span adjustment for each channel to the programmed values.

19. If all channels passed calibration, the following screen sequence occurs.



If any of the sensors cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and lists the sensor(s) that failed to calibrate. In the example below, the oxygen and H_2S channels failed calibration. The other sensors calibrated normally.



The buzzer and alarm LED arrays activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and return to the Calibration Mode Screen. Attempt to calibrate again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

20. Disconnect the tubing from the probe.
21. Unscrew the demand flow regulator from the calibration cylinder.
22. Use the RANGE ▼SHIFT button to place the cursor next to the **NORMAL OPERATION** menu option, then press and release the POWER ENTER RESET button to return to Measuring Mode.

B9.b. RKI Instruments Eagle 2 Operator's Manual

INSTRUMENTS

EAGLE 2

Operator's Manual

Part Number: 71-0154RK

Revision: H

Released: 3/30/12

www.rkiinstruments.com

WARNING

Read and understand this instruction manual before operating instrument. Improper use of the gas monitor could result in bodily harm or death.

Periodic calibration and maintenance of the gas monitor is essential for proper operation and correct readings. Please calibrate and maintain this instrument regularly! Frequency of calibration depends upon the type of use you have and the sensor types. Typical calibration frequencies for most applications are between 1 and 3 months, but can be required more often or less often based on your usage.

Table of Contents

WARNING: ***Understand manual before operating. Substitution of components may impair intrinsic safety. To prevent ignition of a hazardous atmosphere, batteries must only be changed or charged in an area known to be nonhazardous. Not tested in oxygen enriched atmospheres (above 21%).***

NOTE: RKI Instruments, Inc. recommends that you refer to ISA-RP12.13, Part II-1987 or an equivalent international recommended practice for guidance in the use of combustible gas detection instruments.

Chapter 1: Introduction

Overview

This chapter briefly describes the EAGLE 2 gas monitor. This chapter also describes the *EAGLE 2 Operator's Manual* (this document). Table 1 at the end of this chapter lists the specifications for the EAGLE 2.

About the EAGLE 2

Using an advanced detection system consisting of up to six gas sensors, the EAGLE 2 sample draw gas monitor is capable of detecting the presence of combustible gas, oxygen (O_2), carbon monoxide (CO), hydrogen sulfide (H_2S), and various other toxic gases simultaneously. The EAGLE 2's rugged, reliable, and easy-to-use design makes it ideally suited for a wide range of applications, including sewage treatment plants, utility manholes, tunnels, hazardous waste sites, power stations, petrochemical refineries, mines, paper mills, drilling rigs, and fire fighting stations. The EAGLE 2 offers a full range of features including:

- Simultaneous monitoring of one to six gases. The standard configuration includes four sensors for combustible gas (%LEL, ppm, and %volume), oxygen, carbon monoxide (CO), and hydrogen sulfide (H_2S).
- Choice of three operating modes:
    - Normal Mode for typical confined space or area monitoring. Normal Mode is the standard factory setting.
    - Bar Hole Mode for checking of bar holes when searching for underground gas leaks
    - Leak Check Mode for locating leaks in valves and piping
- Sample-drawing pump with up to 125 foot range
- Liquid crystal display (LCD) for complete and understandable information at a glance
- Ultrabright alarm LEDs
- Distinctive audible alarm for dangerous gas conditions or unit malfunction

- Microprocessor control for reliability, ease of use, and advanced capabilities
- Data logging functions (when used in Normal Mode)
- Alarm trend data (when used in Normal Mode)
- STEL and TWA (when used in Normal Mode) and over range alarms
- Peak readings (when used in Normal Mode)
- Built-in time function
- Lunch break feature
- RF shielded high impact plastic case
- CSA classified for Class I, Division I, Groups A, B, C, and D hazardous atmospheres

WARNING: ***The Model EAGLE 2 detects oxygen deficiency, elevated levels of oxygen, combustible gases, carbon monoxide, and hydrogen sulfide, all of which can be dangerous or life threatening. When using the EAGLE 2, you must follow the instructions and warnings in this manual to assure proper and safe operation of the unit and to minimize the risk of personal injury. Be sure to maintain and periodically calibrate the EAGLE 2 as described in this manual.***

NOTE: ONLY THE COMBUSTIBLE GAS DETECTION PORTION OF THIS INSTRUMENT HAS BEEN ASSESSED FOR PERFORMANCE.

Specifications

Table 1: Standard Sensor Specifications

	Combustible Gas, Methane (CH_4) Calibration Standard	Oxygen (O_2)	Hydrogen Sulfide (H_2S)	Carbon Monoxide (CO)
Detection Range	0 - 100 %LEL	0 - 40 volume%	0 - 100.0 ppm	0 - 500 ppm
Reading Increment	1 %LEL	0.1 volume %	0.5 ppm	1 ppm
Alarm 1 Factory Setting	10 %LEL	19.5 volume %	10.0 ppm	25 ppm
Alarm 2 Factory Setting	50 %LEL	23.5 volume %	30.0 ppm	50 ppm
STEL Alarm	n/a	n/a	15.0 ppm	200 ppm
TWA Alarm	n/a	n/a	10.0 ppm	25 ppm

Table 2: EAGLE 2 Specifications

Sampling Method	Sample Draw
Response Time	T90 Within 30 Seconds
Display	Graphics LCD Display
Operating Temperature & Humidity	-20°C to 50˚C/Below 85% RH (Without Condensation)
Indication Accuracy	**Combustible Gas (LEL), Catalytic Type Sensor** • -10°C to 40˚C: 5% of full scale • -20°C to 50˚C: 6% of full scale **Combustible Gas (ppm), Catalytic Type Sensor** • ± 25 ppm or ± 5% of reading (whichever is greater) **Hydrogen Sulfide** • ± 5% of reading or ± 2 ppm H_2S (whichever is greater) **Carbon Monoxide** • ± 5% of reading or ± 5 ppm CO (whichever is greater)

Safety/ Regulatory	186718 CSA classified as Intrinsically Safe. Exia. Class I, Groups A, B, C, & D. Temperature Code T3C.
Power Supply	• Four C size alkaline batteries, standard • Four C size Ni-MH batteries, optional
Continuous Operating Hours @ 25 °C	• Alkaline Batteries: 16 Hours (Non Alarm Operation, Fully Charged) • Ni-MH Batteries: 18 Hours (Non Alarm Operation, Fully Charged)
Case	High-impact Plastic, RF Shielded, Dust and Weather Proof
Standard Accessories	• 5 foot hose • Hydrophobic probe • Shoulder Strap
Optional Accessories	• Rechargeable NiMH Batteries • 115 VAC Charger • 12 VDC Charger • Hoses of Various Lengths, See “General Parts List” on page 81. • Dilution Fitting (1:1 and 3:1) • Various Probes, See “General Parts List” on page 81 • Data Logger Management Program (Windows® 2000, XP, and Vista) • Maintenance Data Loader Program (Windows® 2000, XP, and Vista) • IrDA/USB Cable for connecting to a computer when using the Data Logger Management Program and Maintenance Data Loader Program (not needed if computer has an infrared port)
Dimensions and Weight	Approximately 171(H) x 65(W) x 39(D) mm (5.6”H x 2.5”W x 1.5”D) Approximately 310 g (11 oz.)

About this Manual

The *EAGLE 2 Operator’s Manual* uses the following conventions for notes, cautions, and warnings.

NOTE: Describes additional or critical information.

CAUTION: *Describes potential damage to equipment.*

WARNING: Describes potential danger that can result in injury or death.

The *EAGLE 2 Operator’s Manual* is organized as follows:

- **Chapter 1** is an introduction to the EAGLE 2.
- **Chapter 2** describes the components of the EAGLE 2.

- **Chapter 3** describes the operation of the EAGLE 2.
- **Chapter 4** describes Calibration Mode which allows you to calibrate the EAGLE 2's active channels.
- **Chapter 5** describes the EAGLE 2's maintenance requirements and procedures.
- **Appendix A** describes calibration of the EAGLE 2 using a sample bag.
- **Appendix B** describes Setup Mode which allows you to configure different parameters of the EAGLE 2.
- **Appendix C** describes the sub PCBs that are installed for optional sensors and how they affect gas and channel configuration.
- **Appendix D** describes the PID sensors and the operation of the EAGLE 2 with a PID sensor installed.
- **Appendix E** describes the ESM-01 sensors and the operation of the EAGLE 2 with an ESM-01 sensor installed.
- **Appendix F** describes the TC sensors and the operation of the EAGLE 2 with a TC sensor installed.
- **Appendix G** describes the infrared CO_2 sensors and the operation of the EAGLE 2 with an infrared CO_2 sensor installed.
- **Appendix H** describes the infrared methane sensors and the operation of the EAGLE 2 with an infrared methane sensor installed.
- **Appendix I** describes the infrared hydrocarbon sensor and the operation of the EAGLE 2 with an infrared hydrocarbon sensor installed.
- **Appendix J** describes the operation of the EAGLE 2 in Methane Elimination Mode.
- **Appendix K** describes the operation of the EAGLE 2 in Bar Hole Mode.
- **Appendix L** describes the operation of the EAGLE 2 in Leak Check Mode.
- **Appendix M** describes the Tank Tester Model of the EAGLE 2.
- **Appendix N** describes the operation of the EAGLE 2 in Inert Mode

Chapter 2: Description

Overview

This chapter describes the EAGLE 2 instrument and accessories.

Instrument Description

The EAGLE 2 includes the case, sensors, LCD, control buttons, printed circuit boards, alarm LEDs, infrared communication port, buzzer, battery case and batteries, and flow system.

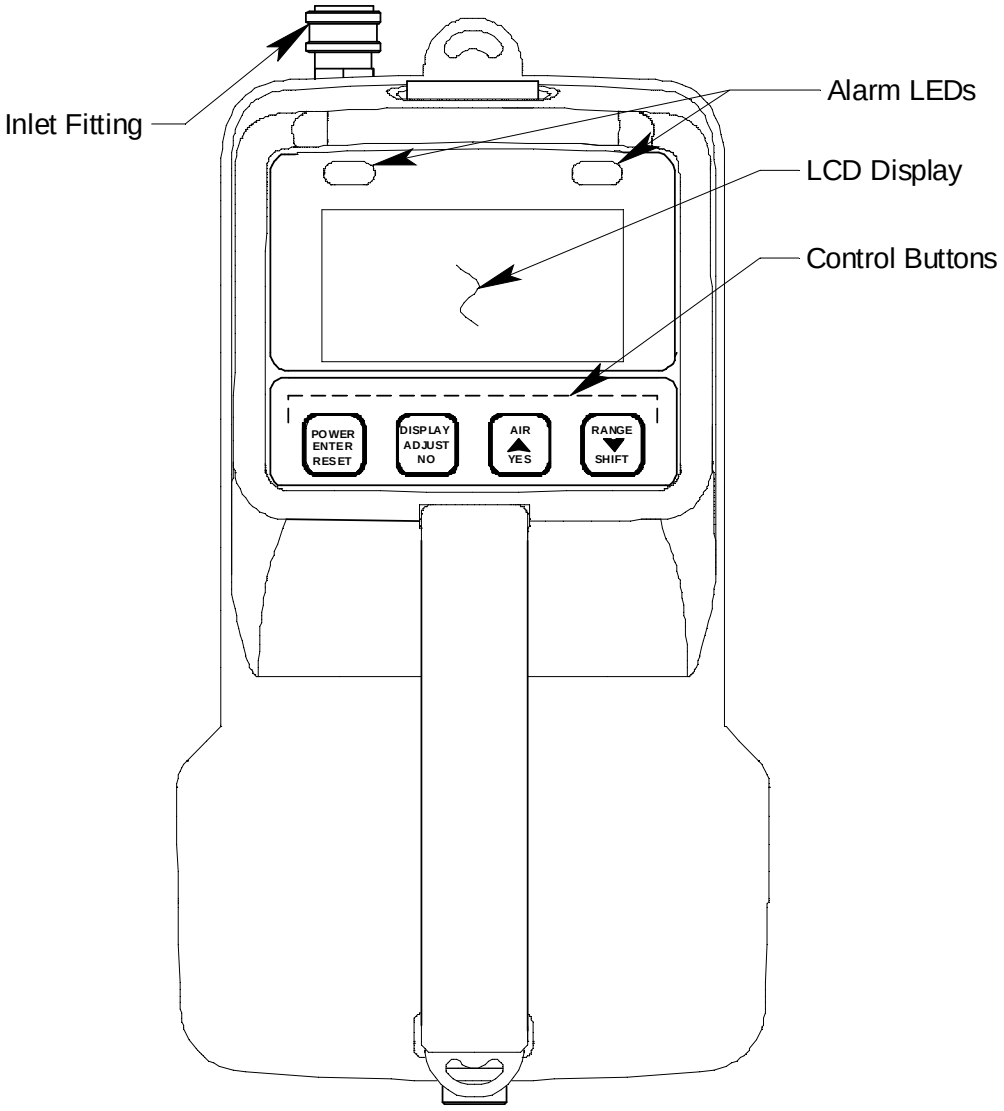


Figure 1: Component Location, Top View

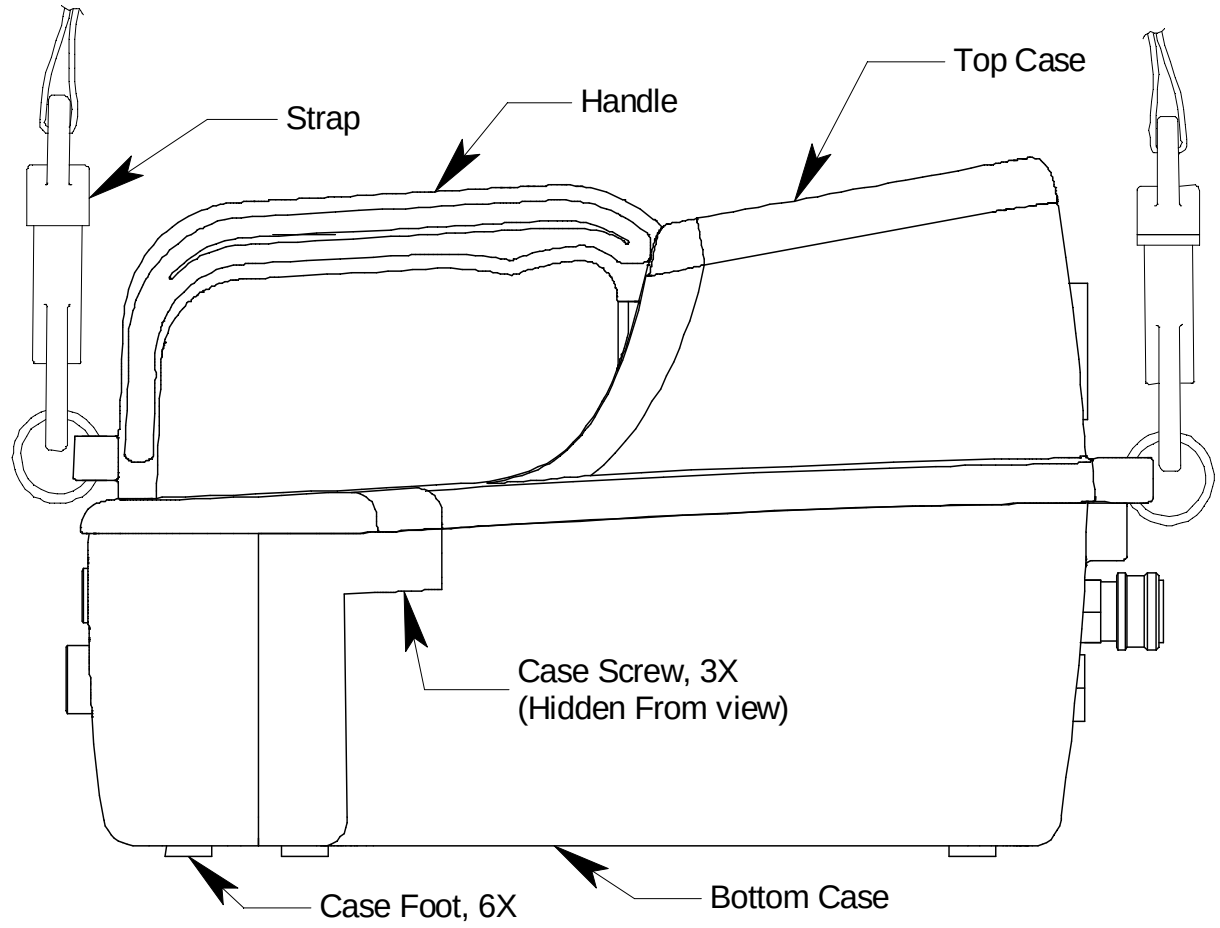


Figure 2: Component Location, Side View

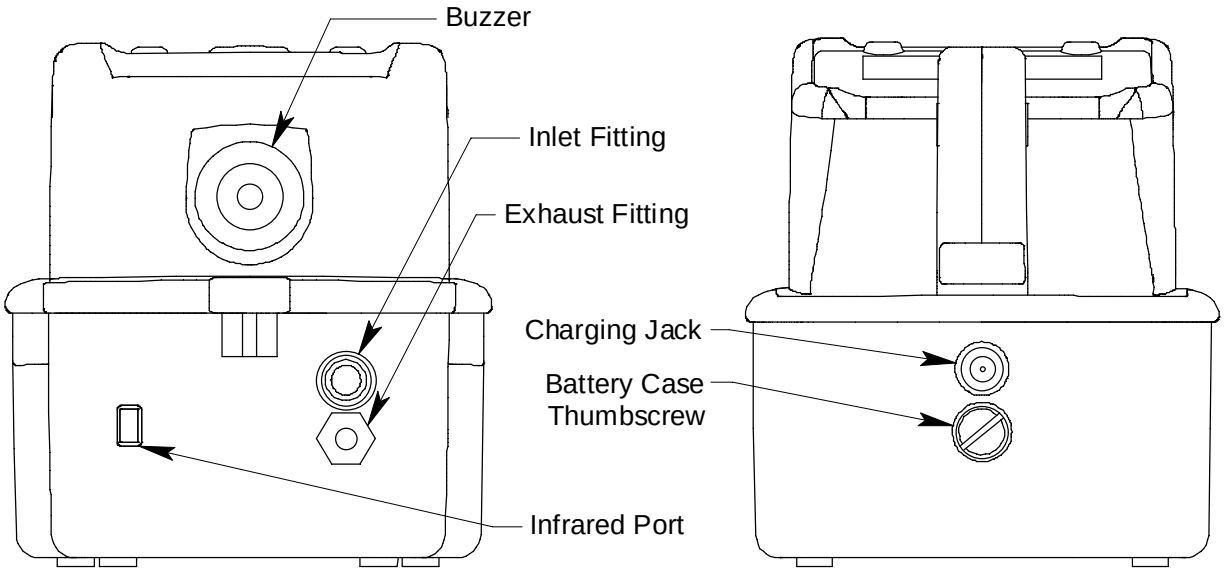


Figure 3: Component Location, Front & Back

Case

The EAGLE 2's sturdy, high-impact plastic case is radio frequency (RF) resistant and is suitable for use in many environmental conditions, indoors and out. The case is dust proof and water resistant. It's two main components, the top case and bottom case, are held together with three screws located on the bottom case. The interface between the top case and bottom case is gasketed. A sturdy, well balanced handle on the top case allows you to hold the instrument comfortably. A clear plastic window is located on the top case to the front of the handle for viewing the LCD.

A removable battery case is located at the rear of the bottom case. A thumbscrew secures the battery case to the bottom case. The interface between the battery case and the bottom case is gasketed. Six raised feet on the bottom of the case, four on the bottom case and two on the battery compartment, raise the EAGLE 2 slightly from the surface on which it rests.

Sensors

The EAGLE 2 uses up to six sensors to monitor combustible gas, oxygen (O_2), carbon monoxide (CO), hydrogen sulfide (H_2S), and various other toxic gases simultaneously. The sensors are located inside the EAGLE 2 bottom case and are installed in the flow chamber. The sensors described below are the four standard sensors. See "Appendix D: PID Sensors" for a description of the PID sensors, "Appendix E: ESM-01 Toxic Sensors" for a description of the ESM-01 toxic sensors, "Appendix F: TC Sensors" for a description of the TC sensors, "Appendix G: Infrared Carbon Dioxide Sensors" for a description of the IR CO_2 sensors, "Appendix H: Infrared Methane Sensor" for a description of the IR methane sensors, and "Appendix I: Infrared Hydrocarbon Sensor" for a description of the IR hydrocarbon sensor. The standard sensors use different detection principles as described below.

Catalytic Combustible Gas Sensor (LEL Sensor)

The catalytic combustible gas (LEL) sensor detects combustible gas in the %LEL range. It uses a catalytic element for detection. The reaction of gas with oxygen on the catalyst causes a change in the resistance of the element which changes the current flowing through it. The current is amplified by the EAGLE 2's circuitry, converted to a measurement of combustible gas concentration, and displayed on the LCD.

The LEL sensor housing includes a sintered metal flame arrestor on

one end that allows gas to diffuse into the sensor. On the other end, five pins extend from the sensor. The sensor cable connects to these pins on one end and terminates in a four-position connector on the other end which plugs into the **HC** socket on the main PCB (see "Main PCB" on page 12).

Oxygen Sensor

The O_2 sensor is a galvanic type of sensor. A membrane behind the openings on the sensor face allows gas to diffuse into the sensor at a rate proportional to the partial pressure of oxygen. The oxygen reacts in the sensor and produces a voltage proportional to the concentration of oxygen. The voltage is measured by the EAGLE 2's circuitry, converted to a measurement of gas concentration, and displayed on the LCD.

The sensor includes a short cable that terminates in a round 7-position connector. It mates with the **OXY** pins on the main PCB (see "Main PCB" on page 12).

CO and H_2S Sensors

The CO and H_2S sensors are electrochemical sensors that consist of three precious metal electrodes in a dilute acid electrolyte. A gas permeable membrane covers the sensor face and allows gas to diffuse into the electrolyte. The gas reacts in the sensor and produces a current proportional to the concentration of the target gas. The current is amplified by the EAGLE 2's circuitry, converted to a measurement of gas concentration, and displayed on the LCD.

The CO and H_2S sensors are physically very similar. Except for their markings and wire colors, they look almost identical. A three-position connector at the end of a 2-wire cable from each sensor plugs into a socket on the main PCB. The sockets on the main PCB for the CO and H_2S sensors are labeled **CO** and **H2S.** Normally, the CO connector plugs into the **CO** socket and the H2S plugs into the **H2S** socket. However, because of the way that the main PCB circuitry is arranged, if the CO sensor is plugged into the H2S socket and the H2S sensor is plugged into the CO socket, the sensors will still operate properly and the CO and H2S readings will still appear on the channels that are programmed for those gases.

LCD

A digital LCD (liquid crystal display) is visible through a clear plastic window in the top case. The LCD simultaneously shows the gas reading for all installed sensors. The LCD also shows information for each of the EAGLE 2's operating modes.

Control Buttons

Four control buttons are located below the LCD. They are, from left to right, POWER ENTER RESET, DISPLAY ADJUST NO, AIR ▲ YES, and RANGE ▼ SHIFT.

Table 3: EAGLE 2 Control Button Functions

Button	Function(s)
POWER ENTER RESET	• turns the EAGLE 2 on and off • silences and resets audible alarm if Alarm Latching is set to **Latching** and Alarm Silence is set to **ON** • enters instructions, values, and settings into the EAGLE 2's microprocessor
DISPLAY ADJUST NO	• activates Display Mode • silences and resets audible alarm if Alarm Latching is set to **Latching** and Alarm Silence is set to **ON** • enters instructions into the EAGLE 2's microprocessor
AIR ▲ YES	• activates the demand zero function (adjusts the EAGLE 2's fresh air reading) • silences and resets audible alarm if Alarm Latching is set to **Latching** and Alarm Silence is set to **ON** • enters instructions into the EAGLE 2's microprocessor • moves the cursor on the LCD up the screen • increases the value of a parameter available for adjustment • scrolls through parameter options
RANGE ▼ SHIFT	• changes the detection units of the combustible gas channel (when Catalytic Units is set to **CHANGE OK** in Setup Mode) • silences and resets audible alarm if Alarm Latching is set to **Latching** and Alarm Silence is set to **ON** • enters instructions into the EAGLE 2's microprocessor • moves the cursor on the LCD down the screen • decreases the value of a parameter available for adjustment • scrolls through parameter options

Printed Circuit Boards (PCBs)

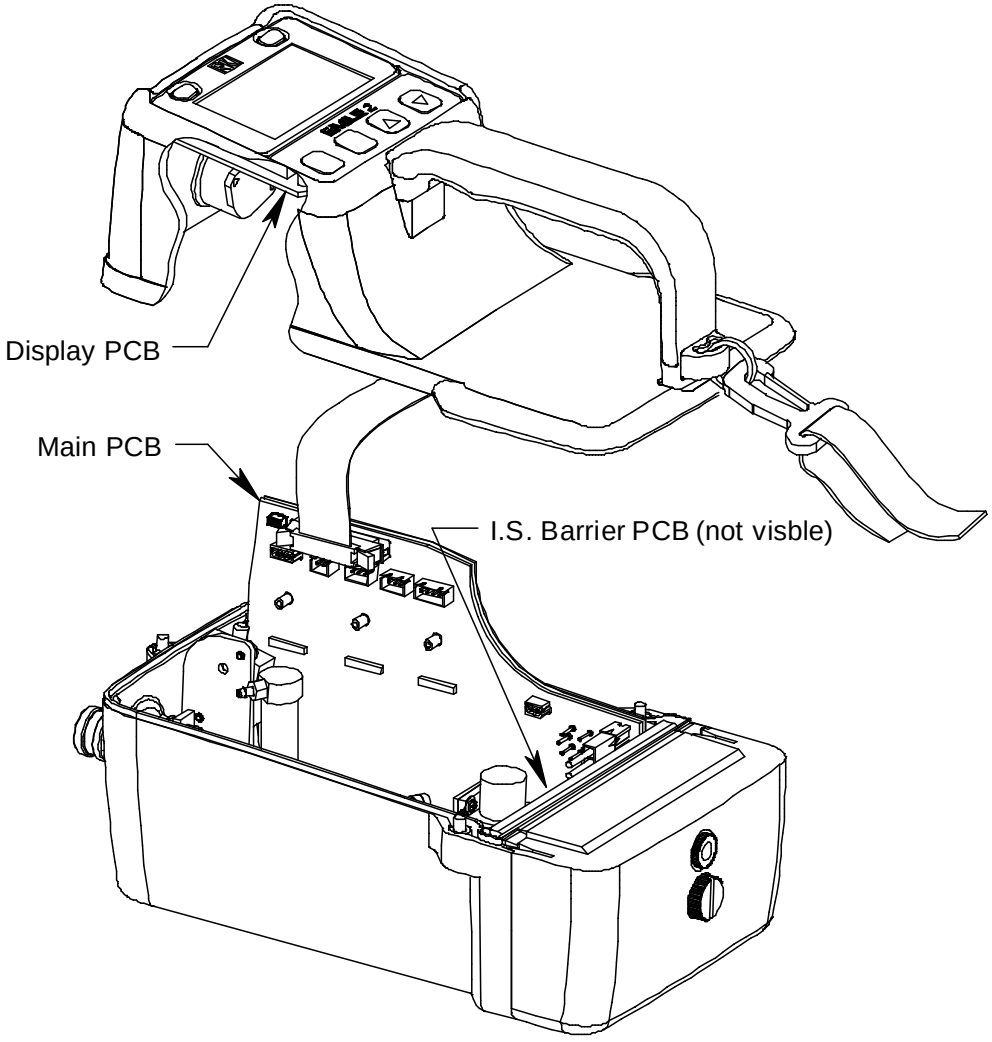


Figure 4: EAGLE 2 PCBs

The EAGLE 2's PCBs analyze, record, control, store, and display the information collected. The main PCB and I.S. barrier PCB are located in the bottom case. The display PCB is located in the top case. The display PCB and I.S. barrier PCB are not user serviceable and are not involved in any user performed maintenance. The main PCB is not user serviceable, but it is involved in the replacement of sensors, so it is described below.

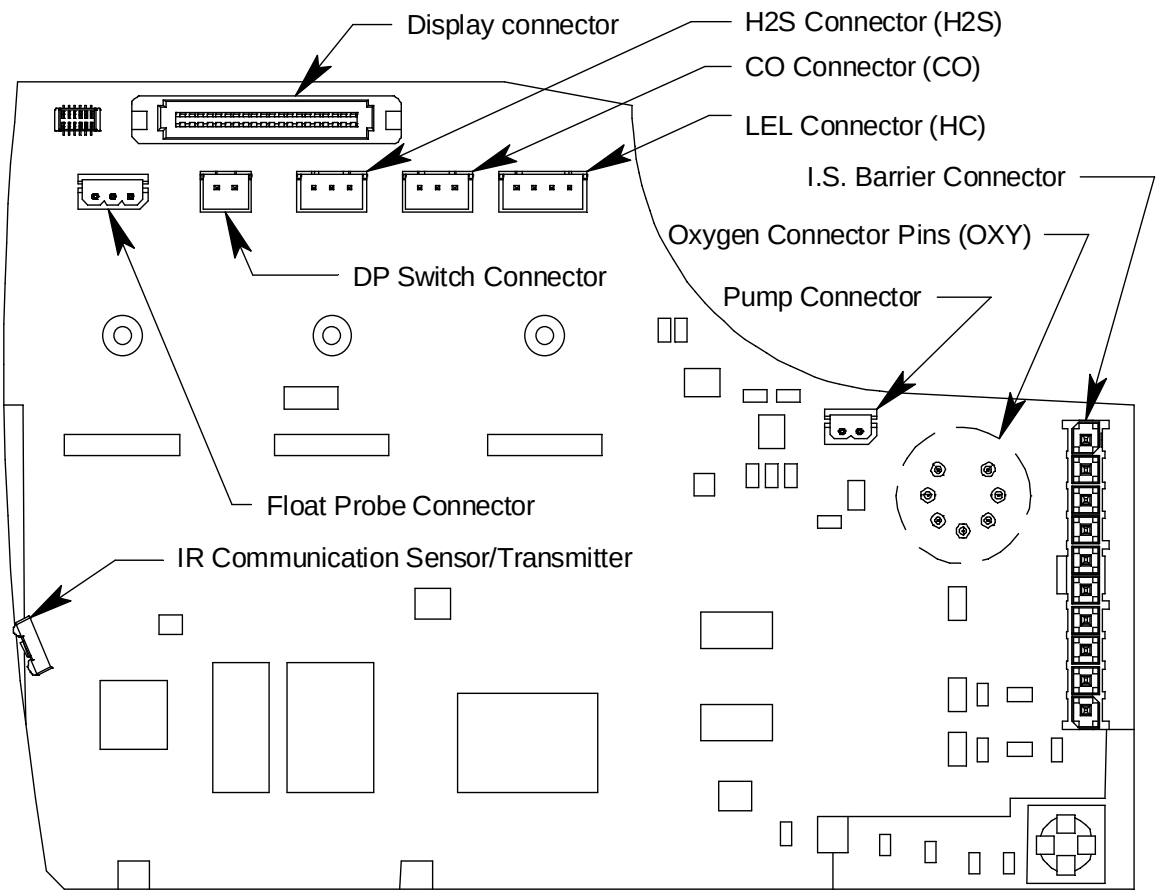


Figure 5: Main PCB

The main PCB is located on the right side of the bottom case. It slides into guiding grooves at the bottom, front, and rear of the bottom case. It is held in place by the top case. Connectors for the sensors, differential pressure switch, pump, display PCB, optional float probe, and I.S. barrier PCB are located on the main PCB. In addition, an IR transmitter / receiver is located at the front of the PCB behind the IR port on the front of the bottom case.

Alarm LEDs

Two sets of red alarm LEDs (light emitting diodes) are visible through two raised, frosted plastic lenses in the top case. Each set has two LEDs. They are above the LCD, one above the left corner and one above the right corner. The alarm LEDs alert you to gas, low battery, and failure alarms.

Infrared Communications Port

An infrared (IR) communications port is located on the left front of the

bottom case when the instrument is viewed from the front. The data transmitted through the port is in standard IrDA protocol. A computer's infrared port or an IrDA / USB cable connected to a USB port can be used to download data saved by the EAGLE 2 to a computer using the Eagle 2 Data Logger Management Program. See the Data Logger Management Program operator's manual for data logging and downloading instructions.

Buzzer

A solid-state electronic buzzer is located on the front of the top case. It is a panel mounting type of buzzer and is water resistant and sealed to the inside of the top case with an O-ring. The buzzer sounds for gas alarms, malfunctions, low battery voltage, and as an indicator during use of the EAGLE 2's many display and adjustment options.

Battery Case & Batteries

Four C-size alkaline batteries (standard) or optional rechargeable C-size Ni-MH batteries power the EAGLE 2. They are installed in the battery case which is located at the rear of the bottom case. The battery case is secured to the bottom case with a thumbscrew.

Instrument run time is dependent upon battery type. At 25°C, alkaline batteries power the EAGLE 2 for 16 hours of non-alarm operation. Ni-MH batteries will power the EAGLE 2 for 18 hours of non-alarm operation. The current battery voltage is viewable in Display Mode (see "Display Mode" on page 39).

When the EAGLE 2 detects low battery voltage, a low battery warning is activated. When battery voltage is too low for operation, the EAGLE 2 sounds a dead battery alarm.

The alkaline or Ni-MH batteries can be accessed for replacement by unscrewing the thumbscrew that secures the battery case to the bottom case and pulling the battery case away from the bottom case. The Ni-MH batteries can be recharged by using the EAGLE 2 charger (see "Replacing or Recharging the Batteries" on page 70).

NOTE: Use of batteries or battery chargers not specified by RKI Instruments, Inc. will void the CSA classification and may void the warranty.

WARNING: ***To prevent ignition of a hazardous atmosphere, batteries must only be changed or charged in an area known to be nonhazardous.***

Flow System

The EAGLE 2 flow system consists of the inlet fitting, hydrophobic filter, pump, internal tubing, differential pressure (DP) switch, sensor chamber, charcoal filter, and exhaust fitting.

Inlet Fitting

The inlet fitting is on the right front (when viewed from the front) of the bottom case. It is a nickel plated brass quick connect fitting. It mates with either the sample hose or with the hydrophobic probe.

Hydrophobic Filter

The hydrophobic filter is located in the bottom case above the sensors. Normally the hydrophobic probe accessory (see “Hose and Probe” on page 15) will prevent water and particulate contamination from entering the flow system, but if the probe is not used, the hydrophobic filter will stop water and particulates from penetrating further into the flow system. If it becomes dirty or water logged, replace it (see “Replacing the Hydrophobic Filter” on page 74).

Pump

A diaphragm pump inside the rear of the bottom case draws the sample to the sensors. It can draw sample from as far as 125 feet from the EAGLE 2.

CAUTION: *Sample hose lengths of more than 125 feet are not recommended for the EAGLE 2 because of flow rate reduction and increased response time. Consult RKI Instruments, Inc. for sample hose lengths longer than 125 feet.*

Internal Tubing

The flow system includes polyurethane tubing to route the sample between the various components of the flow system. The internal sample tubing is not user serviceable.

Differential Pressure (DP) Switch

The DP switch is inside the front of the bottom case. It senses the EAGLE 2’s flowrate by monitoring the pressure drop between points in the flow system. When the flowrate becomes too low for safe operation of the EAGLE 2, a set of contacts inside it open and the EAGLE 2 indicates a low flow alarm.

Sensor Chamber

A PVC block in the bottom case is configured to accept the four gas sensors. It routes the sample to each sensor. The LEL sensor and the

oxygen sensor are retained in the sensor chamber by brackets. The CO and H_2S sensors are each pushed past two sealing O-rings into the chamber and are retained by the O-ring compression force.

Charcoal Filter

The charcoal filter is located in the front of the flow chamber next to the CO sensor. It contains activated charcoal. The CO sensor will respond if exposed to H_2S and certain hydrocarbon gases. The charcoal filter scrubs these gases out of the sample to avoid false CO readings. If false or elevated CO readings are noticed, especially in the presence of H_2S, change the charcoal filter. The charcoal inside the filter cannot be replaced; the entire filter must be replaced.

Exhaust Fitting

The exhaust fitting is located below the inlet fitting. It routes the gas sample out of the EAGLE 2. It includes a female 10-32 thread that can be used for the installation of a hose barb or other type of fitting that has a male 10-32 thread so that the exhaust can be routed to a particular location with flexible tubing if desired.

Standard Accessories

Standard accessories include the shoulder strap, the sample hose, and the hydrophobic probe.

Shoulder Strap

A comfortable elastic shoulder strap clips to the EAGLE 2 at the front and rear of the top case. It clips to stainless steel rings that are installed in features on the top case. It can be removed from the EAGLE 2 by opening the clip at each end of the strap and removing it from the strap ring at the front and rear of the top case.

Hose and Probe

A 5 foot polyurethane sample hose and a 10 inch hydrophobic probe are included as standard. The hose has a male quick connect fitting on one end and a female quick connect fitting on the other end. The probe has a male quick connect fitting. Normally, the male end of sample hose is installed in the EAGLE 2 inlet fitting and the probe is installed in the female end of the hose. However, if the sample hose is not needed for monitoring a particular area, the probe may be installed directly to the inlet fitting. Sample hose lengths are available from 5 feet (standard length) to 125 feet (see “General Parts List” on page 81). A teflon lined hose is provided with all units that contain a

PID sensor. This hose must be used when operating a PID EAGLE 2 (see “Appendix D: PID Sensors” on page 133).

CAUTION: *Sample hose lengths of more than 125 feet are not recommended for the EAGLE 2 because of flow rate reduction and increased response time. Consult RKI Instruments, Inc. for hose lengths longer than 125 feet.*

The probe includes a replaceable hydrophobic filter disk that prevents particulates and water from entering the EAGLE 2’s flow system. See “Replacing the Hydrophobic Probe’s Filter Disk & O-ring” on page 73 for instructions to replace the hydrophobic filter disk.

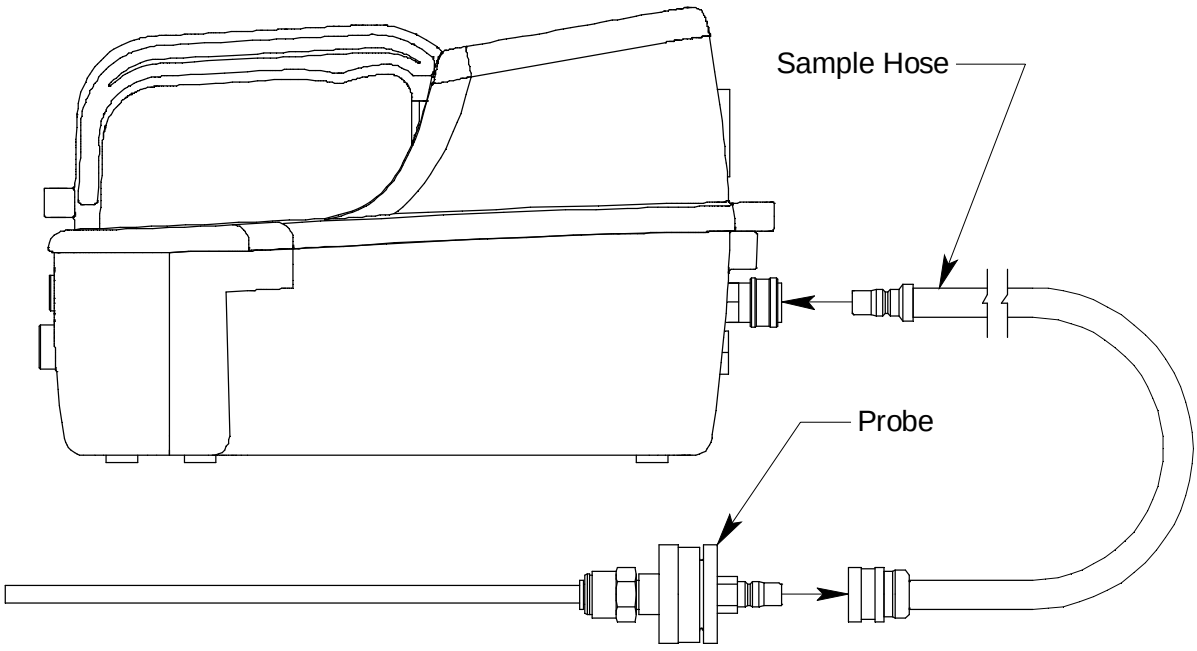


Figure 6: Sample Hose and Hydrophobic Probe

Optional Accessories

Several optional accessories are available for the EAGLE 2. They include rechargeable Ni-MH batteries, battery chargers, various special probes, and dilution fittings. The most commonly used optional accessories are described below. Detailed instructions regarding the use of these and other available accessories are included in other parts of this manual. Data logging accessories are briefly described in “Data Logging” on page 53.

Rechargeable Ni-MH Batteries

Rechargeable Ni-MH batteries are available for the EAGLE 2. A fully charged set of Ni-MH batteries will power the EAGLE 2 for 18 hours. The batteries will last for a minimum of 500 charge cycles. See “General Parts List” on page 81 for ordering information.

Battery Chargers

Three battery chargers are available for the EAGLE 2 to charge the optional Ni-MH batteries, the standard AC charger, a DC charger with a vehicle plug adapter, and an AC/DC charger with a vehicle plug adapter.

AC Charger

The standard AC charger consists of the charging module, which includes all of the charging circuitry, and an AC adapter. The charging module includes a five foot cable with a connector on the end that mates with the EAGLE 2 charging socket. The AC adapter plugs into a 115 VAC wall outlet and connects to the charging module with a jack on the end of a five foot DC output cable. The AC adapter will also work for 100 VAC or 220 VAC if an appropriate plug adapter is provided. The AC charging station is shown below in Figure 7.

Figure 7: EAGLE 2 AC Charger

DC Charger

An optional DC powered charger is available with a vehicle plug 12 VDC adapter. It uses the same charging module as the standard AC charger.

Figure 8: EAGLE 2 DC Charger

AC/DC Charger

A charger is also available that includes both the AC adapter and the 12 VDC vehicle plug adapter. The charging module is the same as the one used for the AC charger and the DC charger.

Optional Probes

Various optional probes designed for specific applications are available for the EAGLE 2. They include the following:

- 10 inch super toxic probe

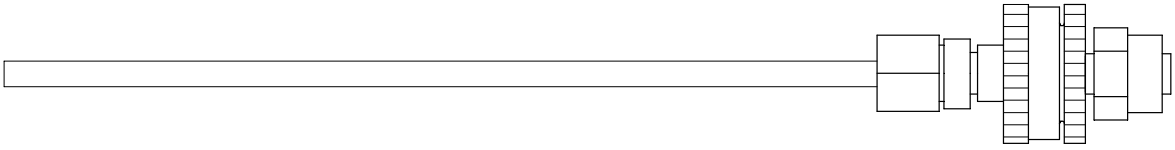


Figure 9: Super Toxic Probe

This probe is used for certain versions of the EAGLE 2 that detect toxic gases that are absorbed by the standard probe. This probe has a plastic fitting that accepts 1/4 inch O.D. rigid plastic tubing instead of the male quick connect fitting used on the standard 10 inch probe. An EAGLE 2 that uses the super toxic probe has an inlet fitting that accepts 1/4 inch O.D. rigid plastic tubing instead of the female quick connect fitting on the standard EAGLE 2.

- 30 inch aluminum probe

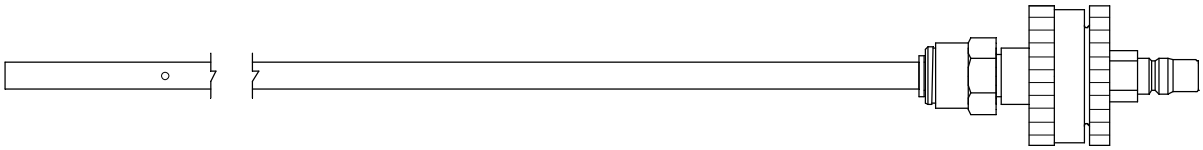


Figure 10: 30 Inch Aluminum Probe

This probe is designed for applications where it is necessary to put the probe tip in areas that are out of reach with the standard probe. A small breather hole near the end of the probe tube prevents interruption of sampling and a low flow alarm if the probe tip is blocked.

- 30 inch stainless steel probe

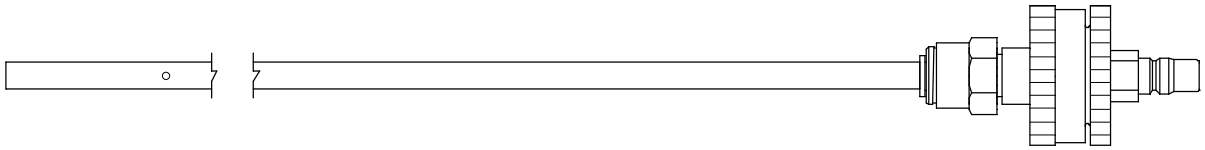


Figure 11: 30 Inch Stainless Steel Probe

This probe is physically the same as the 30 inch aluminum probe and is intended for applications where a high level of corrosion resistance is required in the long probe tube.

- 4 foot stainless steel probe

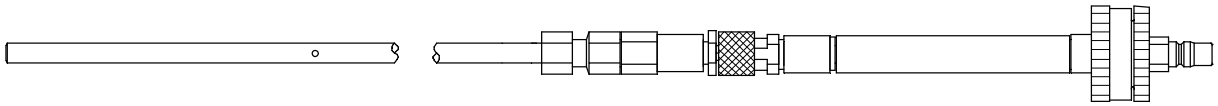


Figure 12: 4 Foot Stainless Steel Probe

This probe is designed for areas where it is necessary to put the probe tip in areas that are out of reach for even the 30 inch probes. A stainless steel probe tube is used because the length of the probe tube requires a high degree of rigidity. Stainless steel is more rigid than other normally used materials. A small breather hole near the end of the probe tube prevents interruption of sampling and a low flow alarm if the probe tip is blocked.

- Barhole probe

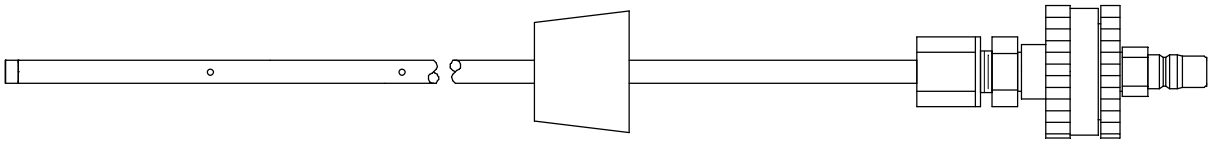


Figure 13: Barhole Probe

This probe is designed specifically for barhole testing. See “Appendix K: Using the EAGLE 2 in Bar Hole Mode” for an in-depth discussion of using the EAGLE 2 in Bar Hole Mode.

- 10 inch probe with dust filter

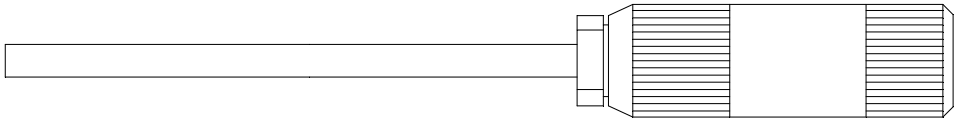
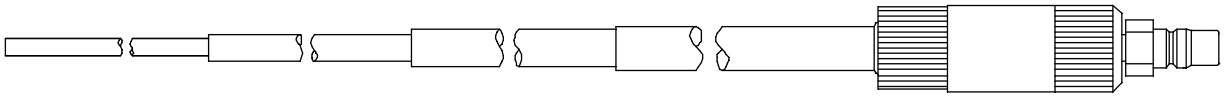


Figure 14: 10 Inch Probe With Dust Filter

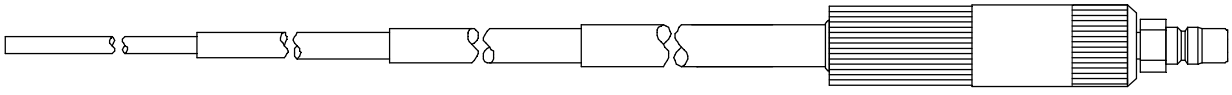
This probe is designed for use where drawing water or moisture into the EAGLE 2 is not a concern. Instead of a hydrophobic filter, a cotton dust filter is used.

- 32 inch telescoping probe with dust filter



This probe is designed for use where it is necessary to put the probe tip in areas not accessible with the 10 inch probe with dust filter and applications where the probe tube must be collapsible for storage.

- 7 foot telescoping probe with dust filter



This probe is designed for use where it is necessary to put the probe tip in areas not accessible with the 32 inch telescoping probe with dust filter and applications where the probe tube must be collapsible for storage.

See “General Parts List” on page 81 for probe ordering information.

External Dilution Fittings

Two external dilution fittings are available for the EAGLE 2, a 1:1 dilution fitting and a 3:1 dilution fitting. They are designed to mate with the inlet fitting and accept a sample hose or probe. The fittings are made with brass and nickel plated brass and are appropriate for use with the four standard gases. The 1:1 fitting is normally used when it is necessary to introduce air into a sample that has no oxygen or a very low level of oxygen, such as a nitrogen purged sample. Both the 1:1 and 3:1 fittings can also be used when one of the target gas levels in the sample area will likely be present in a concentration above the detection range for that gas. Since the fittings partially consist of unplated brass, they are not appropriate for detection of elevated levels of H_2S or of gases that are easily absorbed such as Cl_2 or SO_2.

Figure 15: 1:1 and 3:1 Dilution Fittings

Chapter 3: Operation

Overview

This chapter explains how to use the EAGLE 2 to perform confined space entry monitoring or general area monitoring in Normal Mode. There are three operational modes in Normal Mode: Measuring Mode, Display Mode, and Calibration Mode. While in Normal Mode, the unit is normally operating in Measuring Mode. Display Mode and Calibration Mode are accessible from Measuring Mode. Display Mode is described in this chapter. Calibration Mode is described in “Chapter 4: Calibration Mode” on page 55.

Special versions of the EAGLE 2 can also operate in Leak Check Mode and Bar Hole Mode. See “Appendix K: Using the EAGLE 2 in Bar Hole Mode” and “Appendix L: Using the EAGLE 2 in Leak Check Mode” for operating instructions for Bar Hole and Leak Check Mode, respectively.

Start Up

This section explains how to start up the EAGLE 2, get it ready for operation, and turn it off.

NOTE: The screens illustrated in this section are for a standard 4-gas unit. The screens displayed by your EAGLE 2 may be slightly different.

Turning On the EAGLE 2

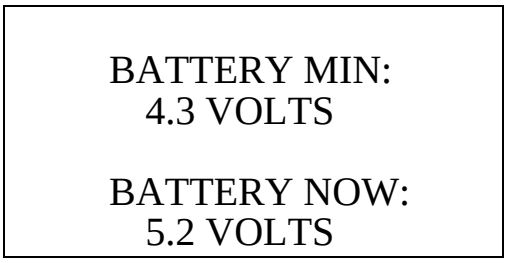
To illustrate certain functions, the following description of the EAGLE 2 start up sequence assumes that the following menu items in Setup Mode are turned on: LUNCH BREAK, CAL REMINDER, and USER/STATION ID. If any of these items are turned off, then the corresponding screens will not appear.

The EAGLE 2 may be used with a sample hose or with the probe installed directly to the inlet fitting. Determine which configuration works best for your application.

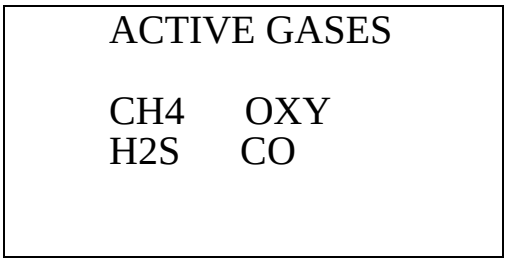
1. Connect the sample hose or probe to the EAGLE 2’s quick connect inlet fitting.
2. If using a sample hose, connect the probe to the sample hose’s quick connect fitting.

3. Press and briefly hold down the POWER ENTER RESET button. Release the button when you hear a beep.
4. The LCD will show the following screen for about ten seconds.

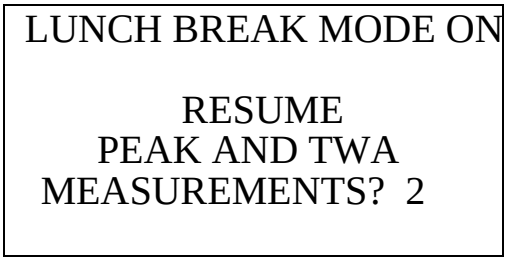
5. The Battery Voltage Screen appears for a few seconds.



6. The Active Gases Screen appears for a few seconds indicating which channels are active and their target gas.



7. If LUNCH BREAK is turned on (see “Updating the Lunch Break Setting” on page 125), the Resume Measurement Screen appears. The unit counts down from 5 seconds in the lower right corner of the LCD to the right of “MEASUREMENTS”.

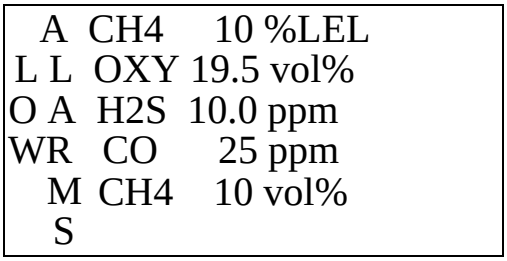


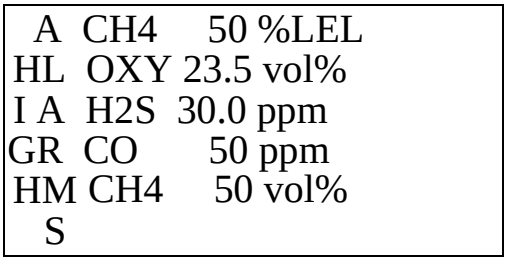
   - To continue accumulating peak and time-weighted average (TWA) readings from the last time the EAGLE 2 was used, press and release the AIR ▲ YES button before the countdown reaches 0 or allow the countdown to reach 0. If you do not press the AIR ▲ YES button within the 5 second countdown, the EAGLE 2 automatically resumes

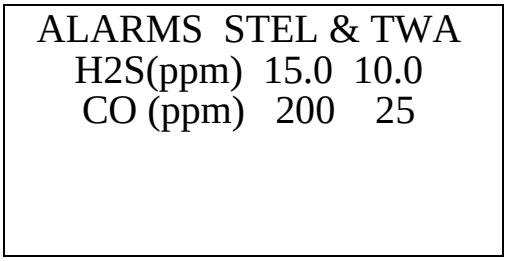
accumulating the peak and TWA readings.The EAGLE 2 will also continue to keep track of operating time including the operating time from the last time the EAGLE 2 was used. See “Time in Operation Screen” on page 51 for more information about how the EAGLE 2 tracks the operating time. The short-term exposure limit (STEL) reading is reset each time the EAGLE 2 is turned on.

- To reset the accumulation of these measurements, press and release the DISPLAY ADJUST NO button before the countdown reaches 0.

8. The gas alarm setpoints are displayed by three screens in sequence: the Low Alarm Screen, High Alarm Screen, and STEL/TWA Alarm Screen. Each screen remains on the LCD for three seconds.

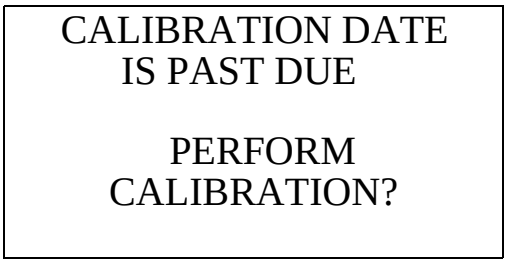






9. After the alarm screens, if CAL REMINDER is turned on, the screen that appears next depends on how CAL PAST DUE ACT is set in the Setup Mode Menu (see “Updating the Calibration Past Due Action Setting” on page 119).

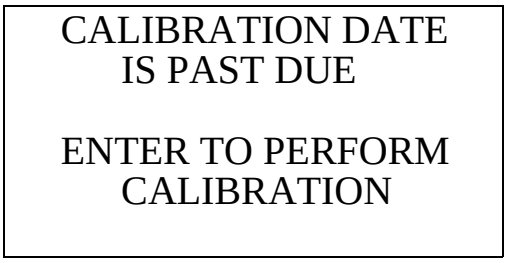
- If the unit is due for calibration and CAL PAST DUE ACT is set to CONFIRM TO CAL, then the following screen displays and the buzzer sounds in a double pulsing pattern.



  To perform a calibration, press and release the AIR ▲ YES button. The EAGLE 2 will enter Calibration Mode and the LCD will show the Calibration Mode main menu. See “Chapter 4: Calibration Mode” on page 55 for instructions to calibrate the EAGLE 2. When you are done with the calibration and exit Calibration Mode, the unit will begin the startup sequence. If the calibration was successful, the screen above will not appear again until the unit is due for calibration. If the calibration was not successful, the screen above will again appear in the startup sequence.

  To continue without performing a calibration, press and release the DISPLAY ADJUST NO button.

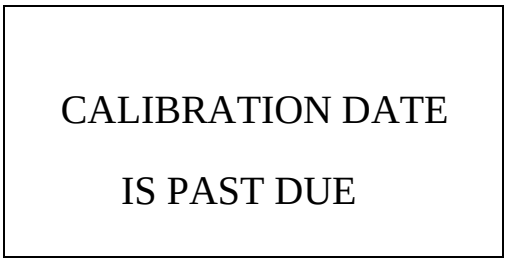
- If the unit is due for calibration and CAL PAST DUE ACT is set to MUST CALIBRATE, then the following screen displays and the buzzer sounds in a double pulsing pattern.



  The EAGLE 2 cannot be used until a successful calibration has been performed. Press and release the ENTER button to enter Calibration Mode. See “Chapter 4: Calibration Mode” on page 55 for instructions to calibrate the EAGLE 2. When you are done with the calibration and exit Calibration Mode, the unit will begin the startup sequence. If the calibration was successful, the screen above will not appear again until the unit is due for calibration. If the calibration was not successful, the screen above will again appear in the startup sequence.

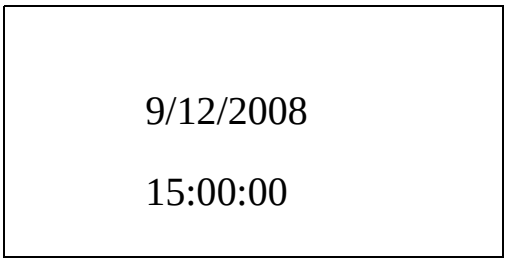
- If the unit is due for calibration and CAL PAST DUE ACT is set to

NOTIFICATION ONLY, then the following alert screen displays and the buzzer sounds in a double pulsing pattern.

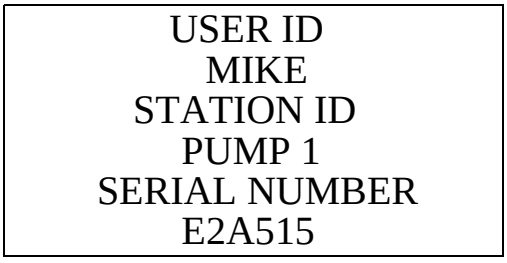


Press and release the POWER ENTER RESET button to acknowledge the alert and continue with the startup sequence.

10. The Date/Time Screen appears for a few seconds.

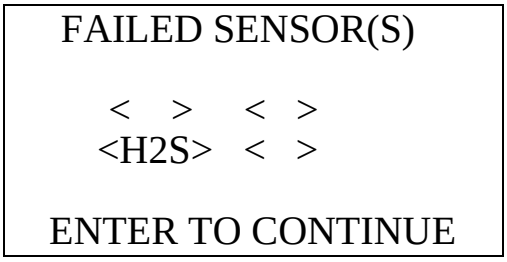


11. If USER/STATION ID is turned on (see “Turning the User/Station ID Function On or Off” on page 113), the ID Screen appears for a few seconds.



If USER/STATION ID is turned off, only the serial number is shown.

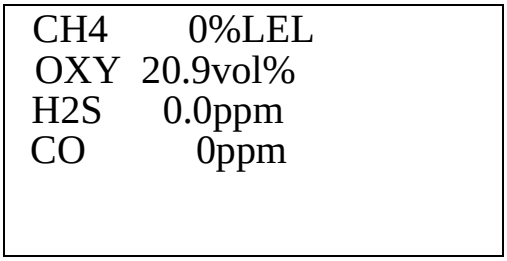
12. If the EAGLE 2 experiences a sensor failure during start up, a screen indicating which sensor failed appears and the buzzer sounds a pulsing tone twice per second. In the example below, the H_2S sensor has failed.



If you wish to continue, press and release the POWER ENTER RESET

button to acknowledge the failure. The gas reading for the failed sensor will be replaced by “XXX”. Replace the failed sensor as soon as possible.

13. The EAGLE 2 is now monitoring for gas in Measuring Mode. The Normal Operation Screen appears displaying the current gas reading for each target gas.



Performing a Demand Zero

Before using the EAGLE 2, it is recommended to set the fresh air readings for the target gases by performing a demand zero. This will set the CH_4, H_2S, and CO channels to zero and the OXY channel to 20.9%.

1. Find a fresh-air environment. This is an environment free of toxic or combustible gases and of normal oxygen content (20.9%).
2. Turn on the unit as described above in “Turning On the EAGLE 2”.
3. Press and hold the AIR ▲ YES button. The LCD prompts you to continue holding the AIR ▲ YES button and the buzzer will pulse while you hold the button.
4. Continue to hold the AIR ▲ YES button until the LCD prompts you to release it. The EAGLE 2 will set the fresh air reading for all channels. Start up is complete and the unit is now ready for monitoring.

Turning Off the EAGLE 2

1. Press and hold the POWER ENTER RESET button.
2. The buzzer will pulse for about five seconds.
3. Release the button when GOODBYE and the RKI logo appear on the display. When GOODBYE and the RKI logo disappear and the backlight turns off, the unit is off.

Using the Battery Charger for Continuous Operation

WARNING: ***Use the EAGLE 2 charger's continuous operation mode to power the EAGLE 2 only if NiMH batteries are installed in the EAGLE 2. Do not use the charger for continuous operation if alkaline batteries are installed.***

The battery charger can be used with an AC adapter or a vehicle plug DC adapter to run the EAGLE 2 in continuous operation instead of charging the batteries.

1. Place the EAGLE 2 in the area to be monitored.
2. Plug the power adapter into either an AC outlet or into a vehicle outlet depending on which charger is being used.
3. Set the switch on the module to "CONT. OPERAT.".
4. Make sure the EAGLE 2 is off.
5. Make sure the adapter and module are connected.
6. Make sure that the batteries are charged.

NOTE: If the batteries are not charged, the EAGLE 2 will not turn on and will instead give a "Charge Batteries" indication when it is powered up after Step 7 below.

7. Insert the module's round plug into the EAGLE 2's charging jack as shown in Figure 16 below.

Figure 16: Connecting the EAGLE 2 to the Charger

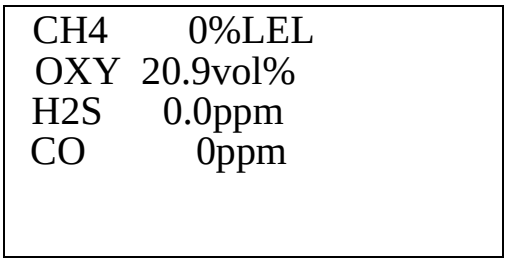
8. See “Chapter 3: Operation” on page 22 for instructions for start-up and operation of the EAGLE 2.
9. While the charging module is powering the EAGLE 2, its amber LED will be off and its green LED will be on.

Measuring Mode, Normal Operation

When the EAGLE 2 completes its startup sequence, it is in Measuring Mode. In Measuring Mode the EAGLE 2 continuously monitors the sampled atmosphere and displays the gas concentrations present for its target gases. In a low-light environment, press and release any button to turn on the display backlight. See “Updating the Backlight Delay Setting” on page 115 to program backlight duration. If the Confirmation Alert feature is turned on in the Setup Mode menu (see “Updating the Confirmation Alert Setting” on page 122), the EAGLE 2 beeps periodically to confirm that it’s operating.

Monitoring an Area

1. Start up the EAGLE 2 as described above in “Start Up” on page 22. It is now in Measuring Mode.



2. Take the EAGLE 2 to the monitoring area.

   Put the probe tip in the area to be monitored.

3. Wait 10 - 15 seconds and observe the display for gas readings. If a reading is observed, allow the reading to stabilize to determine the gas concentrations present.

NOTE: Response time increases with the length of the sample hose. Long sample hoses will require more time to show a response at the EAGLE 2. The maximum sample hose length recommended for the EAGLE 2 is 125 feet. Consult RKI Instruments, Inc. for longer sample hose lengths.

4. If a gas alarm occurs, take appropriate action. See “Responding to

Alarms” on page 37

Using Optional Sample Hoses

The standard sample hose for the EAGLE 2 is 5 feet long. Optional hoses are available up to 125 feet long. If you are considering using a longer hose, keep in mind that a longer hose will increase the EAGLE 2’s response time and the flowrate may decrease close to the low flow alarm point.

CAUTION: *Sample hose lengths of more than 125 feet are not recommended for the EAGLE 2 because of flow rate reduction and increased response time. Consult RKI Instruments, Inc. for hose lengths longer than 125 feet.*

The chart below illustrates how response time is affected by the sample hose length.

Table 4: EAGLE 2 Response Time vs. Sample Hose Length

Hose Used	Typical Time to 90% of Response (T90)
Probe Only	12 seconds
Probe & 5 Foot Hose	15 seconds
Probe & 25 Foot Hose	25 seconds
Probe & 50 Foot Hose	35 seconds
Probe & 75 Foot Hose	45 seconds
Probe & 100 Foot Hose	60 seconds
Probe & 125 Foot Hose	75 seconds

Using Exhaust Tubing

The EAGLE 2’s exhaust fitting has a female 10-32 thread to allow for the installation of a hose barb fitting with a 10-32 thread to which a flexible exhaust tube can be connected. If you utilize this feature, the tubing used must have a minimum internal diameter of 1/8 inch. RKI Instruments, Inc. recommends using flexible polyurethane tubing with a maximum exhaust tube length of 20 feet. Consult RKI Instruments, Inc. for exhaust tubing lengths longer than 20 feet.

Combustible Gas Detection

There are three issues to keep in mind when monitoring for combustible gas.

- The catalytic combustible sensor will respond to any combustible gas. The standard calibration gas for the EAGLE 2 catalytic combustible channel is methane (CH_4). If the instrument is calibrated to a different combustible gas, such as hexane or propane, the gas name for the catalytic combustible channel will reflect the target gas.

  The table below lists the conversion factors for several hydrocarbon gases **if the EAGLE 2 is calibrated to methane**. To use this table, multiply the display reading on the combustible gas channel by the factor in the appropriate row to obtain the actual gas concentration. For example, if you are detecting pentane and the display reads 10% LEL for the catalytic combustible channel, you actually have 10% LEL x 1.35 = 13.5% LEL pentane present.

Table 5: Full Response Mode Conversion Factors (Methane Calibration)

Target Gas	LEL Factor	PPM Factor	Target Gas	LEL Factor	PPM Factor
Acetone	1.49	0.74	Isobutane	1.51	0.54
Benzene	2.58	0.62	Isopropanol	2.17	0.87
Butyl Acrylate	*	0.85	Methane	1.00	1.00
Butyl Acetate	3.42	0.89	Methanol	1.49	1.79
2-Butyl Alcohol	2.14	0.73	Methyl Acetate	1.40	0.87
1-Butyl Alcohol	4.39	1.23	Methyl Acrylate	2.12	1.19
Cyclohexane	2.72	0.71	Methyl Ethyl Keytone	2.66	0.74
Cumene	4.46	0.80	Methyl Isobutyl Keytone	3.33	0.80
Ethylene Dichloride	5.21	6.46	Mixed Xylenes	3.47	0.76
Ethyl Alcohol	1.47	0.97	Nonane	4.24	0.68
Ethyl Chloride	1.52	1.00	Pentane	1.38	0.41
Ethyl Acrylate	3.38	0.95	Propane	1.23	0.51
Hexane	2.56	0.56	Styrene	4.46	0.80
Hydrogen	1.24	0.99	Toluene	3.21	0.70
			Vinyl Acetate Monomer	2.36	1.23

* Vapor pressure too low for significant LEL reading

- The EAGLE 2 provides the catalytic combustible sensor with some

protection against exposure to high levels of combustible gas which can damage the sensor. It does this by turning off the combustible sensor power temporarily when it determines that an over scale (more than 100% LEL) concentration of combustible gas is present that may damage the sensor. Nevertheless, concentrations of combustible gas of more than 100% LEL can still affect the zero level or calibration of the combustible sensor if the concentration is high enough.

CAUTION: *Do not expose the catalytic combustible sensor to high concentrations of combustible gas such as that from a butane lighter. Exposure to high concentrations of combustible gas may adversely affect the performance of the sensor.*

CAUTION: *Any rapid increase in the combustible gas reading on the catalytic combustible channel followed by a declining or erratic reading may indicate a gas concentration above the LEL which may be hazardous.*

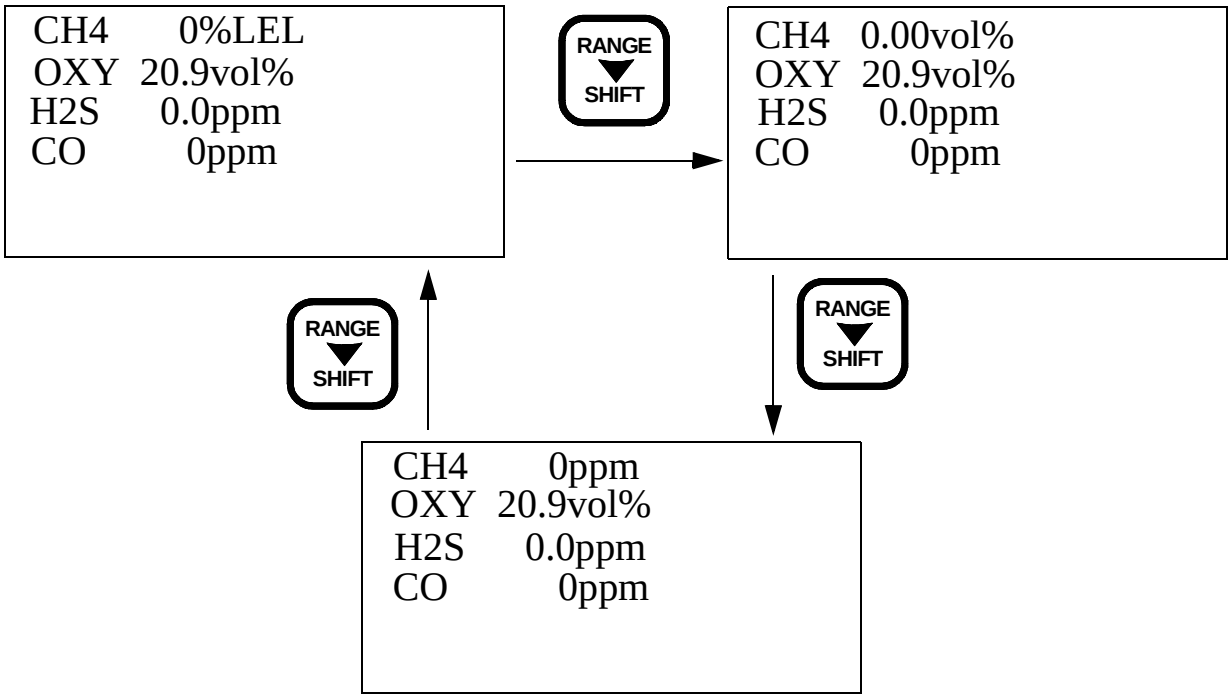
- Some gases such as silicone vapors, chlorinated hydrocarbons, and sulphur compounds can contaminate the detection elements inside the combustible sensor damaging the sensor and result in reduced response to combustible gas. Make every effort to avoid these gases. The catalytic combustible sensor has an integral H_2S scrubber for protection from H_2S exposure resulting from normal use, but you should avoid exposure to high levels of H_2S and other sulphur compounds.

Monitoring Combustible Gas in the PPM or %Volume Ranges

The standard factory configuration for the EAGLE 2 allows the user to use the RANGE ▼SHIFT button to change the displayed detection units of the catalytic combustible channel between %LEL, ppm, and %volume. It is possible to disable this capability and set the EAGLE 2 to display only one of the detection units by using the Catalytic Units menu item in Setup Mode. See “Setting the Catalytic Detection Units” on page 109 for instructions to set this Setup Mode Menu item.

The detection range of the combustible catalytic channel when set for ppm or %volume will correspond to 0 - 100% LEL for the configured gas. For example, the LEL for methane (CH_4) is 5% volume, or 50,000 ppm. So if the catalytic combustible channel is displayed in terms of %volume, the full scale is 5.00% and if it is displayed in terms of ppm, the full scale is 50,000 ppm.

If the Catalytic Units menu item in Setup Mode is set to **CHANGE OK**, the standard factory setting, then you can change the catalytic combustible channel's units by pressing and releasing RANGE ▼ SHIFT.



Monitoring Combustible Gas in the PPM Range

There are special considerations that must be taken into account when monitoring combustible gas in the ppm range with the catalytic combustible channel. Because of the high sensitivity in the lower part of the ppm range, the catalytic combustible channel needs more time than the warm-up period to stabilize after the EAGLE 2 is turned on if it is going to be used for ppm level detection. The reading increments in the ppm range are smallest in the lower part of the range and increase as the reading increases as follows:

- 5 ppm increments from 0 ppm to 200 ppm
- 10 ppm increments from 200 ppm to 1,000 ppm
- 50 ppm increments from 1,000 ppm to 10,000 ppm
- 250 ppm increments from 10,000 ppm to 50,000 ppm

If the catalytic combustible channel is configured for the user defined gas in Setup Mode (see "Configuring the Combustible Gas" on page 104), the ppm ratio defined for the gas must be considered. For example, if the ppm ratio is set higher than 50,000 ppm, then when the display units are set as ppm, the reading will not go above 50,000 ppm

which is equivalent to 33 % LEL and 5 %volume. So if the gas reading is higher than 50,000 ppm, the ppm unit reading will indicate 50,000 ppm and also indicate an overscale condition. The %LEL and %volume unit readings will still increase up to 100% LEL and 15 %volume respectively, which are equivalent to 150,000 ppm.

The catalytic combustible sensor is slightly affected by humidity. This is not apparent when the EAGLE 2 is used for %LEL or %volume detection, but because of the high sensitivity in the ppm range, significant humidity changes can affect the ppm reading, especially in the lower part of the range. Take care to allow the unit to acclimate to a new environment for about a minute and perform a demand zero in a fresh air location when you move between areas of different humidity.

To monitor for combustible gas in the ppm range:

1. Start up the EAGLE 2 as described in “Start Up” on page 22.
2. Allow the EAGLE 2 to run for 3 - 5 minutes after the startup sequence is complete and it is in Measuring Mode. This allows the catalytic combustible sensor to stabilize sufficiently for ppm monitoring.

NOTE: This extra stabilization period is not necessary if monitoring in the %LEL or %volume range.

3. Set the catalytic combustible channel’s units to be ppm by using the RANGE ▼ SHIFT button.
4. Perform a demand zero as described in “Performing a Demand Zero” on page 27.
5. Proceed to monitor for gas as described in “Monitoring an Area” on page 29.

Measuring Mode, Alarms

This section covers alarm indications in Measuring Mode. It also describes how to reset the EAGLE 2 after an alarm has occurred and how to respond to an alarm condition.

NOTE: False alarms may be caused by radio frequency (RF) or electromagnetic (EMI) interference. Keep the EAGLE 2 away from RF and EMI sources such as radio transmitters or large motors.

Alarm Indications

The EAGLE 2 will sound an alarm and flash the LED arrays when one of the target gas concentrations rises above the Low Alarm level, or in the case of oxygen falls below the Low Alarm level, for that gas.

The EAGLE 2 also sounds an alarm and flashes the LED arrays when one of the target gas concentrations rises above the High Alarm level and when the STEL and TWA alarm levels are reached for CO and H_2S.

NOTE: If an alarm condition occurs while you are in Display Mode, the EAGLE 2 will automatically bring up the alarm screen instead.

When a failure condition occurs, such as a sensor failure, low flow, or dead battery condition, the unit will also sound an alarm and flash the LED arrays.

The table below summarizes the types of alarms produced by the EAGLE 2 and their indications.

Table 6: Alarm Types and Indications

Alarm Type	Visual Indications	Audible Indication
Low Alarm Concentration of gas rises above the Low Alarm setting or falls below the Low Alarm setting for O_2.	• **ALRM1** appears next to gas reading • Alarm LED arrays flash once per second • Backlight turns on	Pulsing tone once per second
High Alarm Concentration of gas rises above the High Alarm setting.	• **ALRM2** appears next to gas reading • Alarm LED arrays flash twice per second • Backlight turns on	Pulsing tone twice per second
TWA or STEL Concentration of CO or H_2S rises above the TWA or STEL alarm setting.	• Alarm LED arrays flash once per second • Backlight turns on • **TWA** or **STEL** appears next to gas reading	Pulsing tone once per second
Over Range	• **OVER** appears next to gas reading • Gas reading indicates full scale • Alarm LED arrays flash twice per second • Backlight turns on	Pulsing tone twice per second

Table 6: Alarm Types and Indications

Alarm Type	Visual Indications	Audible Indication
Low Flow	• The display indicates **FAIL LOW FLOW LEVEL** • Alarm LED arrays flash in a double pulsing pattern once per second • Backlight turns on	Double pulsing tone once per second
Low Battery Warning	• **BATT** appears vertically along the left side of LCD	None
Dead Battery Alarm	• Gas readings replaced by **RECHARGE INSTRUMENT BATTERIES** • Alarm LED arrays flash in a double pulsing pattern once per second	Double pulsing tone once per second
Sensor Failure	• **FAILED SENSOR(S)** appears at the top of the display and the failed sensor(s) are indicated • Alarm LED arrays flash in a double pulsing pattern once per second	Double pulsing tone once per second

Resetting and Silencing Alarms

You can set the EAGLE 2's gas alarms as latching or self-resetting alarms (see "Updating the Alarm Latching Setting" on page 112).

- Self-resetting alarms (ALARM LATCHING set to SELF RESET)

  Self-resetting alarms automatically shut off and reset when the gas reading falls below (or rises above for an oxygen low alarm) the alarm setting. You cannot reset self-resetting alarms with the POWER ENTER RESET button. You can set self-resetting alarms with or without the alarm silence feature (see "Updating the Alarm Silence Setting" on page 113).

- Latching alarms (ALARM LATCHING set to LATCHING)

  Latching alarms will remain in effect until the gas reading falls below (or rises above for an oxygen low alarm) the alarm setting and they are reset with the POWER ENTER RESET button. You can set latching alarms with or without the alarm silence feature (see "Updating the Alarm Silence Setting" on page 113).

ALARM SILENCE On and Alarms Set to LATCHING:

ALARM SILENCE set to ON and ALARM LATCHING set to LATCHING are the factory settings. When the EAGLE 2 goes into gas alarm, press and release any button to silence the buzzer. If the gas concentration was still above the alarm level when the button was pressed, the LED arrays continue to flash, and the EAGLE 2 continues to display the current alarm level.

The gas reading must fall below (or rise above for an oxygen low alarm) an alarm setting before you can reset the alarm. When the alarm condition passes, press and release the POWER ENTER RESET button to reset the alarm. The LED arrays turn off and the EAGLE 2 alarm indications on the display turn off.

ALARM SILENCE Off and Alarms Set to LATCHING:

The gas reading must fall below (or rise above for an oxygen low alarm) an alarm setting before you can reset the alarm. When the alarm condition passes, press and release the POWER ENTER RESET button to reset the alarm. The LED arrays and buzzer turn off and the EAGLE 2 alarm indications on the display turn off.

ALARM SILENCE On and Alarms Set to SELF RESETTING:

When the EAGLE 2 goes into gas alarm, press and release any button to silence the buzzer. The POWER ENTER RESET button will not reset the alarm. When the gas reading falls below (or rises above for an oxygen low alarm) an alarm setpoint, the alarm will automatically reset. The LED arrays turn off and the EAGLE 2 alarm indications on the display turn off.

With ALARM SILENCE Off and Alarms Set to SELF RESETTING:

When the EAGLE 2 goes into gas alarm, the POWER ENTER RESET button will not silence or reset the alarm. When the gas reading falls below (or rises above for an oxygen low alarm) an alarm setpoint, the alarm will automatically reset. The LED arrays and buzzer turn off and the EAGLE 2 alarm indications on the display turn off.

Responding to Alarms

This section describes response to gas, over range, battery, and sensor failure alarms.

Responding to Gas Alarms

1. Determine which gas alarm has been activated.
2. Follow your established procedure for an increasing gas condition or a decreasing oxygen condition.

3. If necessary, reset the alarm using the POWER ENTER RESET button once the alarm condition has passed.

Responding to Over Range Alarms

WARNING: An over range condition may indicate an extreme combustible gas, toxic gas, or oxygen concentration. Confirm a normal condition with a different EAGLE 2 or with another gas detecting device.

1. Determine which channel is in alarm.
2. Follow your established procedure for an extreme gas condition.
3. Reset the alarm using the POWER ENTER RESET button once the alarm condition has cleared.
4. Calibrate the EAGLE 2 as described in "Chapter 4: Calibration Mode" on page 55.
5. If the over range condition continues or if you are not able to successfully calibrate the unit, you may need to replace the sensor that has triggered the over range alarm.
6. If the over range condition continues after you have replaced the sensor, contact RKI Instruments, Inc. for further instructions.

Responding to Battery Alarms

WARNING: The EAGLE 2 is not operational as a gas monitoring device during a dead battery alarm. Take the Model EAGLE 2 to a non-hazardous area and replace or recharge the batteries as described in "Replacing or Recharging the Batteries" on page 70.

The EAGLE 2 is fully functional during a low battery warning. However, only a limited amount of operating time remains, approximately 1 - 2 hours. The amount of time depends on how often the LCD backlight is used and how often the unit is responding to alarm conditions. Recharge the Ni-MH batteries or replace the alkaline batteries as soon as possible as described in "Replacing or Recharging the Batteries" on page 70.

NOTE: Alarms and the LCD back light consume battery power and reduce the amount of operating time remaining.

Responding to Sensor Failure Alarms

1. Determine which sensor has triggered the sensor failure alarm.
2. Try calibrating the sensor first, as described in “Chapter 4: Calibration Mode” on page 55 before replacing it.
3. If the sensor failure continues, replace the sensor as described in “Replacing a Sensor” on page 77.
4. If the sensor failure condition continues after you have replaced the sensor, contact RKI Instruments, Inc. for further instructions.

Display Mode

Two other operating modes are accessible when the EAGLE 2 is in Measuring Mode. They are Display Mode and Calibration Mode. This section describes using the EAGLE 2 in Display Mode. In Display Mode you can:

- display peak readings
- display the minimum operating and current battery voltage
- select how the active channels are displayed on the LCD
- turn the catalytic LEL sensor on or off (if there is a TC or infrared combustible channel along with a catalytic combustible channel)
- enable or disable methane elimination mode (if the catalytic combustible gas channel is configured appropriately in the **CONFIGURE GASES** item in Setup Mode)
- temporarily configure the catalytic combustible channel for a target gas other than the one used for calibration (if the **RELATIVE RESPONSE** item in Setup Mode is set to **ON**)
- display STEL readings *(H_2S and CO only)*
- display TWA readings *(H_2S and CO only)*
- display alarm settings
- select the user ID (if the **USER/STATION ID** item in Setup Mode is set to **ON**)
- select the station ID (if the **USER/STATION ID** item in Setup Mode is set to **ON**)
- display time in operation
- display date and time

- display remaining data logging time and clear data logger memory (if the **DATA LOG MEMORY** item in Setup Mode is set to **ON**)

Tips for Using Display Mode

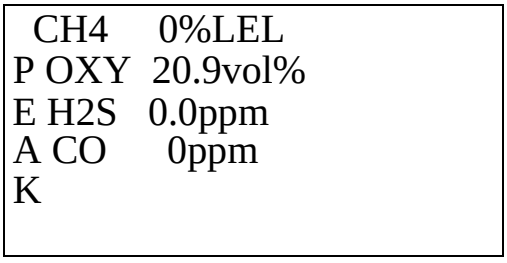
- To enter Display Mode and scroll from one screen to the next or skip an item when a question is asked, press and release the DISPLAY ADJUST NO button.
- To enter an item when a question is asked, press and release the AIR ▲ YES button.
- To change a flashing parameter, use either the AIR ▲ YES button or RANGE ▼ SHIFT button.

NOTE: Each screen displays for 20 seconds. If you do not press a button within 20 seconds, the EAGLE 2 automatically returns to Measuring Mode.

Peak Screen

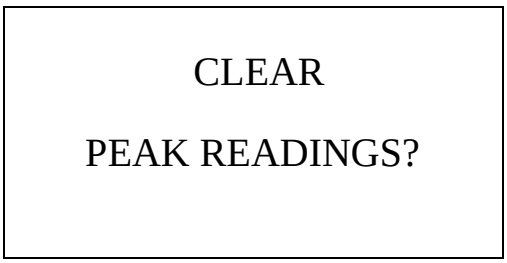
The peak screen displays the highest (lowest for oxygen) concentrations detected since the EAGLE 2 was turned on. Peak readings are stored in the EAGLE 2's memory until a higher level is detected (lower for oxygen), the peak reading is cleared, or the EAGLE 2 is turned off.

The lunch break feature enables the EAGLE 2 to save peak readings when it is turned off so it can continue them when it is turned on again. See "Turning On the EAGLE 2" on page 22



To clear the peak readings, do the following:

1. With the Peak Screen displayed, press and release the POWER ENTER RESET button. The following screen will appear.

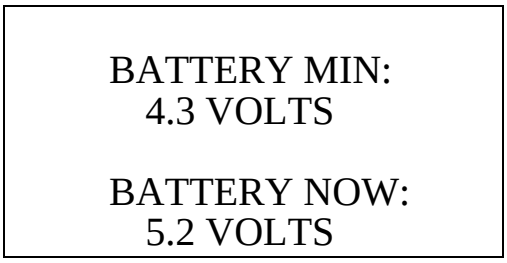


2. Press and release the AIR ▲ YES button. The peak readings will be reset and the unit will return to the Peak Screen.

   If you do not want to clear the peak readings, press and release the DISPLAY ADJUST NO button and the unit will return to the Peak Screen without clearing the peak readings.

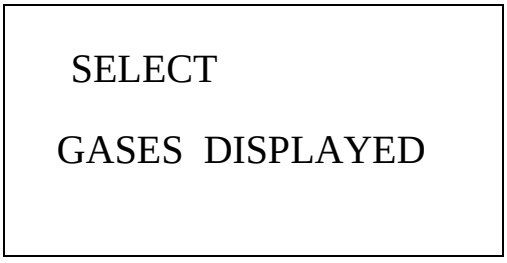
Battery Voltage Screen

The Battery Voltage Screen displays the minimum operating voltage and the current battery voltage. Fully charged alkaline batteries typically indicate 6.0 volts; fully charged Ni-MH batteries typically indicate 5.2 volts. This screen also displays during the startup sequence.



Gas Display Screen

The Gas Display Screen gives you the option to select how the active channels are displayed.



You can display all of them on the screen at the same time, one at a time with automatic scrolling, or one at time with manual scrolling. The factory setting displays all of the active channels at the same time.

To select how to display the active channels, do the following:

1. With the Gas Display Screen displayed, press and release the AIR ▲ YES button. The following screen will appear with the cursor blinking.

2. Use the AIR ▲ YES and RANGE ▼ SHIFT buttons to place the cursor next to the desired choice.
3. Press and release the POWER ENTER RESET button. The unit continues to the STEL Screen and the display configuration will reflect your choice when you return to Measuring Mode.

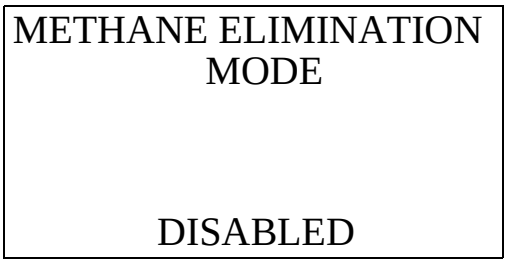
   If you do not want to change the setting, press and release the DISPLAY ADJUST NO button and the unit will return to the Gas Display Screen.

Catalytic (LEL) Sensor Screen

This screen appears only when either a TC sensor or an infrared combustible sensor is installed in an EAGLE 2 along with a catalytic combustible LEL sensor. See “Appendix F: TC Sensors”, “Appendix H: Infrared Methane Sensor”, or “Appendix I: Infrared Hydrocarbon Sensor” for a description of this screen and instructions to use it.

Methane Elimination Mode Screen

This screen displays only if the EAGLE 2 catalytic combustible channel is setup for one of the gases in the CONFIGURE GASES menu item in Setup Mode that supports methane elimination (See “Configuring the Combustible Gas” on page 104).



The standard setup for methane (CH_4) does not support methane elimination. When applicable, use this screen to enable and disable

the methane elimination feature. See “Appendix J: Methane Elimination Mode” for more discussion of the methane elimination feature.

1. With the Methane Elimination Mode Screen displayed, press and release the AIR ▲ YES or RANGE ▼ SHIFT button to toggle to the desired setting, ENABLED or DISABLED.
2. Press and release the POWER ENTER RESET button. The unit will save the setting and proceed to the next menu item.

   If you changed the setting and do not want to save the change, press and release the DISPLAY ADJUST NO button to continue to the next menu item without saving the change.

Catalytic Sensor Relative Response Screen

This screen displays only if **RELATIVE RESPONSE** in Setup Mode is set to ON (see “Updating the Catalytic Sensor Relative Response Setting” on page 110). Use this screen to temporarily change the gas configuration of the catalytic combustible channel.

```
SELECT
RELATIVE RESPONSE
TO CALIBRATED GAS
FOR CATALYTIC SENSOR
```

You can select from a list of gases whose response relative to the configured gas, normally methane, is programmed into the EAGLE 2’s memory. This includes several pre-defined gases and 5 gases that can be entered into the EAGLE 2 in the field using the Eagle 2 Maintenance Data Loader Program. In order to program a field defined gas into the EAGLE 2, gas testing must be performed to determine the gas’ response factor relative to methane. See the Eagle 2 Maintenance Data Loader Program Operator’s manual for details regarding the gas testing and programming user defined gases into the EAGLE 2’s relative response list. The last five items in the gas list are reserved for field defined gases.

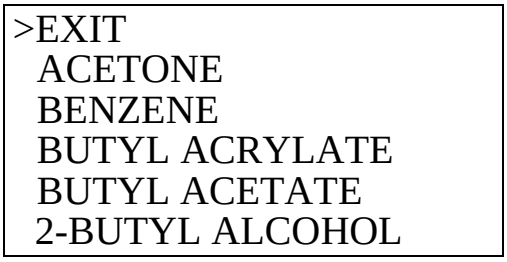
The relative response feature enables you to temporarily monitor for the selected gas without having to recalibrate the EAGLE 2. The EAGLE 2 will clear the gas configuration change when it is turned off and will return to the programmed configuration when it is turned on again.

Because of normal variation between sensors, these relative response

factors are typical factors. If you use this feature, the response to the selected gas will not be as accurate as it would be if you configured and calibrated the catalytic combustible channel to the target gas.

NOTE: For maximum accuracy, configure and calibrate the EAGLE 2's catalytic combustible channel to the desired target gas.

1. With the Relative Response Screen displayed, press and release AIR ▲ YES. A list of gases will appear on the screen with **EXIT** at the top of the list. There are multiple screens of gases.



The following is the complete list of factory defined gases.

Table 7: Relative Response Gas List

Acetone	Cumene	Isobutane	Methyl Ibutyl Ketone	Mixed Xylenes
Benzene	Ethylene Dichloride	Isopropanol	Nonane	Field Defined Gas
Butyl Acrylate	Ethyl Alcohol	Methane	Pentane	Field Defined Gas
Butyl Acetate	Ethyl Chloride	Methanol	Propane	Field Defined Gas
2-Butyl Alcohol	Ethyl Acrylate	Methyl Acetate	Styrene	Field Defined Gas
1-Butyl Alcohol	Hexane	Methyl Acrylate	Toluene	Field Defined Gas
Cyclohexane	Hydrogen	Methyl Keytone	Vinyl Acetate	

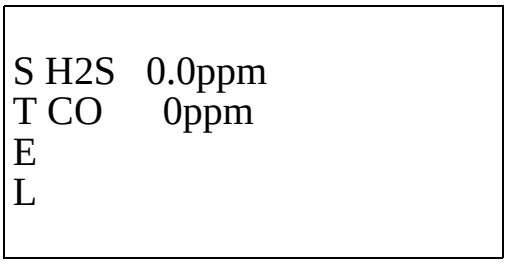
2. Use the AIR ▲ YES or RANGE ▼ SHIFT buttons to move the cursor next to the desired gas.
3. Press and release POWER ENTER RESET. The catalytic combustible channel will be configured to the selected gas and the EAGLE 2 will proceed to the STEL Screen. This configuration will be in force until either a different gas is selected in Display Mode or the unit is turned off.

NOTE: If a PID sensor is installed in the EAGLE 2 and **CATALYTIC SENSOR RELATIVE RESPONSE** is set to ON in Setup Mode, a PID Sensor Relative Response Screen appears after the Catalytic Sensor Relative Response Screen. If **CATALYTIC SENSOR RELATIVE RESPONSE** is set to OFF, the PID Sensor Relative Response Screen will still appear after the Methane Elimination Mode Screen. See "PID Relative Response Feature" on page 136 for a description of the relative response feature for the PID sensor.

NOTE: If Methane Elimination Mode is enabled, the Catalytic Sensor Relative Response screen does not appear.

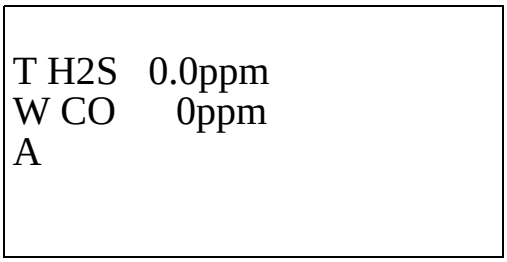
STEL Screen

The STEL Screen displays the short term exposure limit (STEL) readings *for H_2S and CO only.* The STEL reading is the average reading *over the last 15 minutes*.



TWA Screen

The TWA Screen displays the time weighted average (TWA) readings *for H_2S and CO only.*

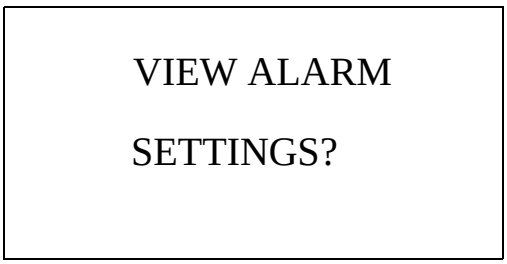


The TWA reading is the average reading *over the last 8 hours*. If 8 hours have not elapsed since the last time the TWA reading was cleared, the average is still calculated over 8 hours. The missing time is assigned a 0 value for readings. If the lunch break feature is turned off, the TWA is cleared when the EAGLE 2 is turned off.

The lunch break feature enables the EAGLE 2 to remember TWA readings when it is turned off so it can continue them when it is turned on again. See "Turning On the EAGLE 2" on page 22

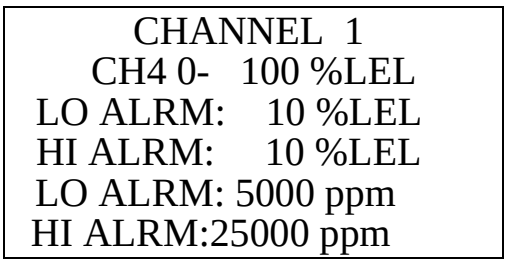
View Alarm Settings Screen

The View Alarm Settings Screen gives you the option to view the gas alarm settings for all active channels.

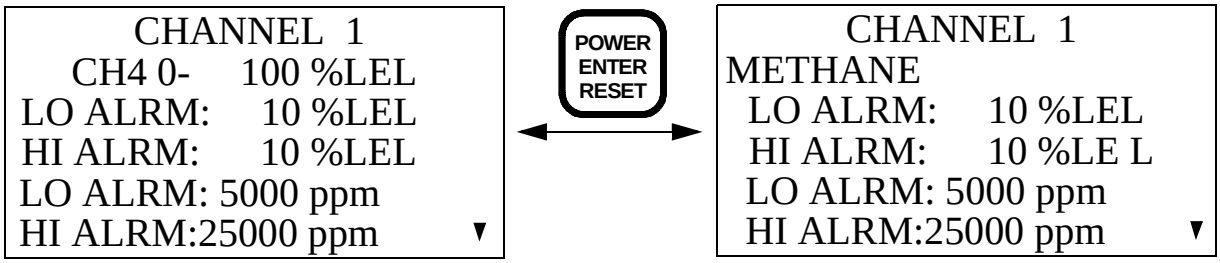


To view the gas alarm settings, do the following:

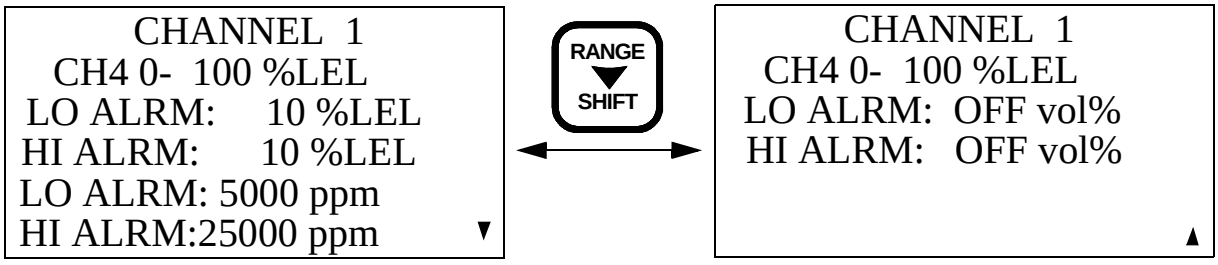
1. With the View Alarm Settings Screen displayed, press and release the AIR ▲ YES button. The following screen appears showing Channel 1 alarm points.



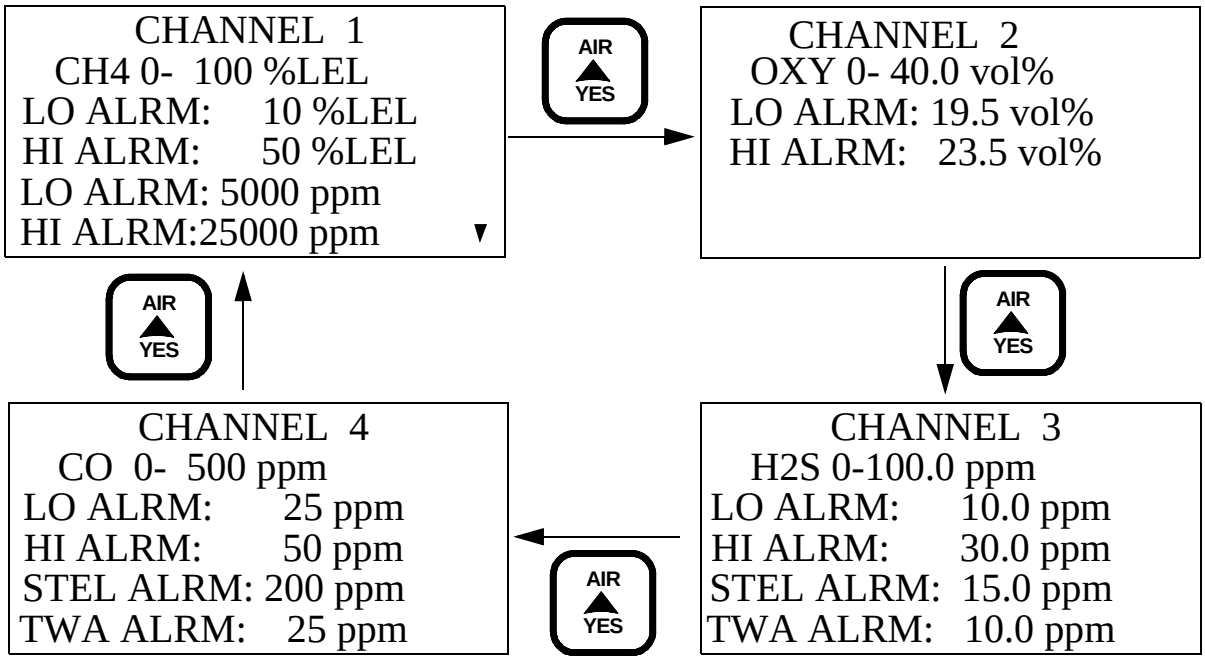
2. If the channel description is too long to fit across the screen, press and release the POWER ENTER RESET button to view the remainder of the displayed channel's description. Press and release the POWER ENTER RESET button again to return to the previous screen.



3. If the number of alarm settings is too many to display on one screen, a down arrow will appear in the lower right corner of the display indicating that there are additional alarm points. Press and release the RANGE ▼ SHIFT button to scroll down and display the remainder of the gas alarm settings for the displayed channel and again to return to the previous screen.

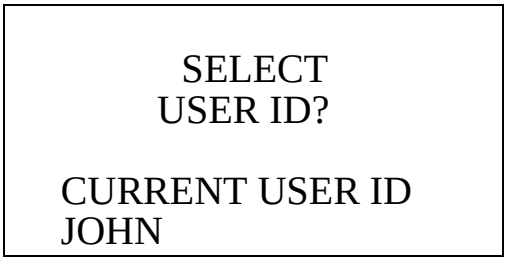


4. Press and release the AIR ▲ YES button to scroll through screens that display the rest of the active channels' alarm settings.



Select User ID Screen

This screen displays only if USER/STATION ID in the Setup Mode menu is set to ON (see "Turning the User/Station ID Function On or Off" on page 113). Use this screen to select a user ID from the user ID list in the EAGLE 2's memory. The current user ID is displayed. A user ID can be up to 16 characters long. The EAGLE 2 can store up to 32 user IDs.

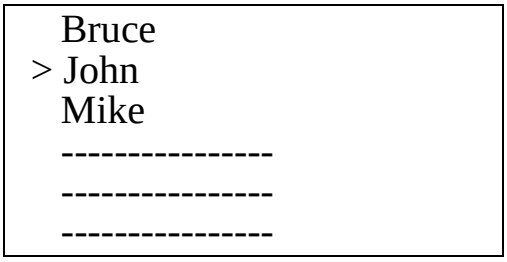


The user ID provides a way to identify the EAGLE 2 user during a data logging session. If the user ID is changed during an operating session, a new data session is initiated with the new user ID attached to it. This allows you to change the user ID during operation and have each user ID that was used during an operating session saved for the corresponding data. See the Eagle 2 Data Logger Management Program Operator's Manual for a detailed description of data logging and the user ID.

The user ID list cannot be edited using the EAGLE 2 user interface. The Eagle 2 Maintenance Data Loader Program is required to define or change user IDs in the user ID list. For a detailed description of editing the list of user IDs stored in the EAGLE 2, see the Eagle 2 Maintenance Data Loader Program Operator's Manual.

To select a different user ID:

1. With the Select User ID Screen displayed, press and release the AIR ▲ YES button. A screen appears that includes the current user ID which is indicated by the cursor next to it.



   The user IDs are displayed in groups of six. The previous group of six is displayed when the cursor is moved up past the top of the LCD. The next group of six is displayed when the cursor is moved down past the bottom

of the LCD. The list will not “wrap around” to the previous screen if the cursor is moved up from the first user ID or to the next screen if the cursor is moved down from the last user ID. Any of the user IDs in the list that have not been changed from the factory setting will be shown as dashes (-).

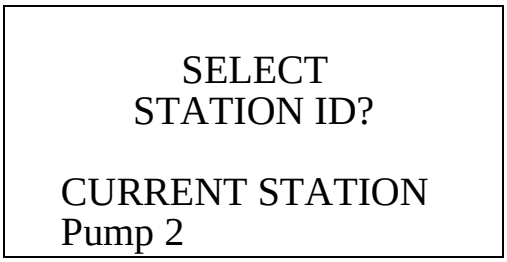
2. Use the AIR ▲ YES and RANGE ▼ SHIFT buttons to move the cursor up and down the screen and scroll through the available user IDs to find the desired user ID.
3. When the desired user ID is displayed, place the cursor next to it, press and release the POWER ENTER RESET button.

NOTE: To exit the selection screen without saving a change, press and release the DISPLAY ADJUST NO button. You will return to the Select User ID screen without saving the user ID change.

4. The unit will save the selected user ID as the current one and proceed to the Select Station ID Screen.

Select Station ID Screen

This screen displays only if USER/STATION ID in the Setup Mode menu is set to ON (see “Turning the User/Station ID Function On or Off” on page 113). Use this screen to select a station ID from the station ID list in the EAGLE 2’s memory. The current station ID is displayed. A station ID can be up to 16 characters long. The EAGLE 2 can store up to 128 station IDs.



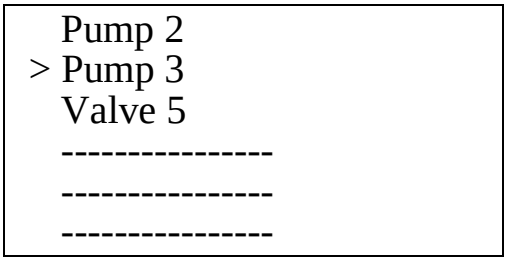
The station ID provides a way to identify a location where monitoring was done during a data logging session. If the station ID is changed during an operating session, a new data session is initiated with the new station ID attached to it. This allows you to change the station ID during operation and have each station ID that was used during an operating session saved for the corresponding data. See the Eagle 2 Data Logger Management Program Operator’s Manual for a detailed description of data logging and the station ID.

The station ID list cannot be edited using the EAGLE 2 user interface. The Eagle 2 Maintenance Data Loader Program is required to define

or change station IDs in the station ID list. For a detailed description of editing the list of station IDs stored in the EAGLE 2, see the Eagle 2 Maintenance Data Loader Program Operator's Manual.

To select a different station ID:

1. With the Select Station ID Screen displayed, press and release the AIR ▲ YES button. A screen appears that includes the current station ID which is indicated by the cursor next to it.



   The station IDs are displayed in groups of six. The previous group of six is displayed when the cursor is moved up past the top of the LCD. The next group of six is displayed when the cursor is moved down past the bottom of the LCD. The list will not "wrap around" to the previous screen if the cursor is moved up from the first station ID or to the next screen if the cursor is moved down from the last station ID. Any of the station IDs in the list that have not been changed from the factory setting will be shown as dashes (-).

2. Use the AIR ▲ YES and RANGE ▼ SHIFT buttons to move the cursor up and down the screen and scroll through the available station IDs to find the desired station ID.

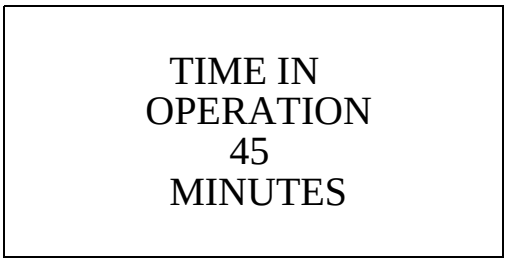
3. When the desired station ID is displayed, place the cursor next to it, press and release the POWER ENTER button.

NOTE: To exit the selection screen without saving a change, press and release the DISPLAY ADJUST NO button. You will return to the Select Station ID screen without saving the station ID change.

4. The unit will save the selected station ID as the current one and proceed to the Time in Operation Screen.

Time in Operation Screen

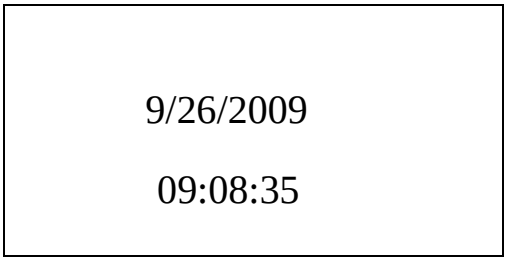
The Time In Operation Screen displays the length of time since the EAGLE 2 was turned on if the lunch break feature is turned off. With the lunch break feature turned off, the time in operation is reset when the EAGLE 2 is turned off. See “Updating the Lunch Break Setting” on page 125 for a description of the lunch break feature.



If the lunch break feature is turned on, the time in operation will only be reset if you do not choose to resume the peak and TWA measurements when the EAGLE 2 is turned on in the Resume Measurement Screen described in Step 7 on page 23 in “Turning On the EAGLE 2”. If you choose to resume the peak and TWA measurements during startup, the EAGLE 2 will include the time in operation when the unit was last turned off in the current time in operation.

Date/Time Screen

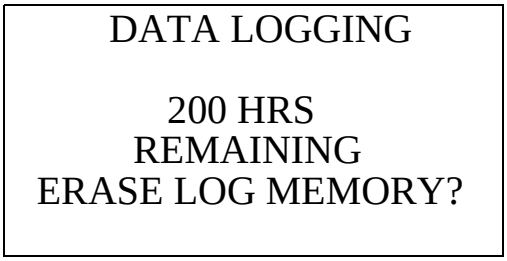
The Date / Time Screen displays the current date and time.



Data Logging Screen

CAUTION: *Once you clear the data logger, you cannot retrieve any data previously stored in the data logger.*

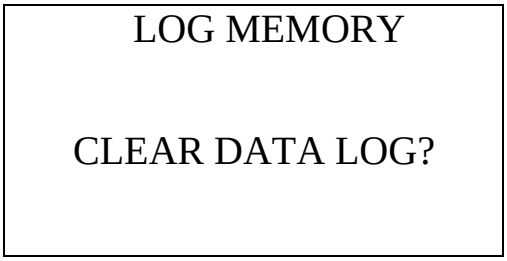
The Data Logging screen displays the time remaining until the data logger memory is full and asks if you want to clear the data logger memory.



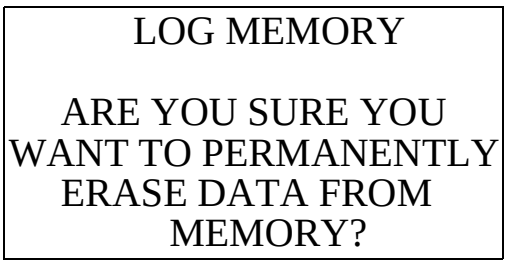
To return to Measuring Mode while at the Data Logging Screen, press and release the DISPLAY ADJUST NO button.

To clear the data logger memory, do the following:

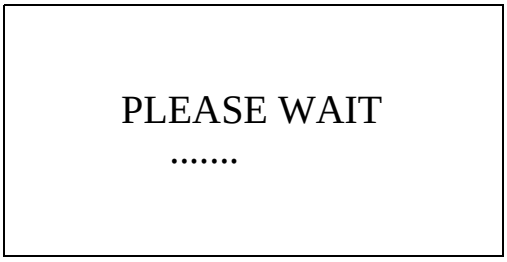
1. With the Data Logging Screen displayed, press and release the AIR ▲ YES button. The following screen appears asking you to confirm that you want to clear the data logger memory.



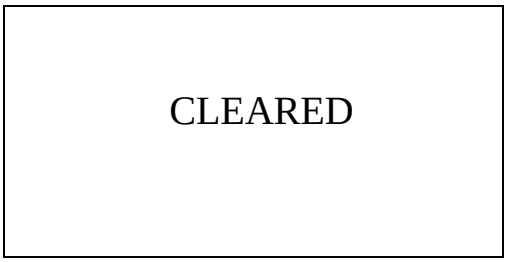
2. If you do not want to clear the data logger memory at this point or at Step 3 below, press and release the DISPLAY ADJUST NO button. The unit will return to Measuring Mode.
3. If you want to clear the data logger memory, press and release the AIR ▲ YES button. The following screen appears asking you to reconfirm that you want to clear the data logger memory.



4. If you want to clear the data logger memory, press and release the AIR ▲ YES button. The unit will display the following screen as it clears the data.



5. The periods below "PLEASE WAIT" will disappear one at a time from right to left as the data is cleared. When the last period disappears, the unit is finished clearing the data and will display the following screen for a few seconds, then return to Measuring Mode.



Data Logging

NOTE: The EAGLE 2 only logs data while in Normal Mode. If the EAGLE 2 is used in Leak Check Mode or Bar Hole Mode, no downloadable data will be logged while it is in either of these two modes.

The EAGLE 2 features the ability to log data to its internal memory and download it to a computer via the infrared communications port on the front of the unit. It logs gas readings during normal operation, alarm data, and calibration data.

To utilize the EAGLE 2's downloading capability, you will need the Eagle 2 Data Logger Management Program and a computer with an infrared port or a USB port that runs one of the following operating systems: Windows 2000, Windows XP, or Windows Vista. If your computer has an infrared port, then no additional accessories are needed to download data from the EAGLE 2. If your computer does not have an infrared port but does have a USB port, a USB/IrDA adapter cable can be used to download data from the EAGLE 2 using the USB port. The Eagle 2 Data Logger Management Program is available from RKI Instruments, Inc. The adapter cable is also available from RKI Instruments, Inc. or may be purchased from an

electronic supply website.

The data logging capacity depends on how often the EAGLE 2 stores data, how many channels are active, and how often the EAGLE 2 is turned on and off. The table below illustrates how much data logging time is available for the various interval times. It assumes that the unit is setup with four sensors, is only turned on once, and there are no alarm occurrences. See “Updating the Data Log Interval Setting” on page 116 for instructions on setting the data logging interval time.

Table 8: Data Logging Capacity, 4-gas EAGLE 2

Interval Time	Data Logging Time
5 seconds	239 hours (10 days)
10 seconds	479 hours (20 days)
20 seconds	959 hours (40 days)
30 seconds	1439 hours (60 days)
1 minute	2879 hours (120 days)
3 minutes	8639 hours (360 days)
5 minutes	14,399 hours (600 days)
10 minutes	28,798 hours (2,000 days)

For a complete description of the Data Logger Management Program and procedures for downloading data to a computer, see the Eagle 2 Data Logger Management Program Operator’s Manual.

Chapter 4: Calibration Mode

Overview

This section describes the EAGLE 2 in Calibration Mode. In Calibration Mode, you can move through a menu of screens to do the following:

- Perform a span adjustment on all channels simultaneously using auto calibration
- Perform a span adjustment on one channel at a time using single calibration
- Perform a fresh air (zero) adjustment

NOTE: You can set up the EAGLE 2 to alert you during the startup sequence when calibration is due. See “Updating the Calibration Reminder Setting” on page 118

CAUTION: *BEFORE EACH DAY’S USAGE, SENSITIVITY IN THE %LEL RANGE MUST BE TESTED ON A KNOWN CONCENTRATION OF THE COMBUSTIBLE TARGET GAS, METHANE, EQUIVALENT TO 25 - 50% OF FULL SCALE CONCENTRATION (the %LEL full scale is 100 %LEL). ACCURACY MUST BE WITHIN -0 to + 20% OF ACTUAL. ACCURACY MAY BE CORRECTED BY FOLLOWING THE CALIBRATION INSTRUCTIONS FOR THE COMBUSTIBLE CHANNEL BELOW.*

If the combustible channel passes the above response test and does not require calibration, the unit should still be calibrated periodically. The optimum frequency of calibration depends heavily on how the EAGLE 2 is used. For example, instruments used daily may need to be calibrated weekly or monthly, while instruments that are used only a few times a year may need to be calibrated before each use. Typical calibration frequencies range from monthly to quarterly. Make sure to perform the combustible channel response test as described above and make sure to develop a calibration schedule tailored to your application that takes this test and required calibration resulting from this test into account.

Calibration Supplies and Equipment

To calibrate the EAGLE 2, you will need:

- Known calibrating samples of the gases being detected. The combustible and toxic gas samples should have concentrations in approximately the middle of the detection range. An oxygen-free source, such as 100% nitrogen is recommended for setting the oxygen zero.

CAUTION: *When using auto calibration with the standard 4-gas EAGLE 2, although the EAGLE 2 can be calibrated with an oxygen concentration of up to 19.5%, RKI Instruments, Inc. recommends that the multi-gas cylinder have an oxygen concentration in the range of 10% - 16% oxygen.*

- A demand-flow regulator to provide adequate sample gas flow
- Non-absorbent tubing

WARNING: ***If you are using a calibration kit that includes a gas bag and a fixed flow regulator or dispensing valve, do not apply gas directly to the EAGLE 2 with the regulator or dispensing valve or damage to the pump will result. See "Appendix A: Calibrating with a Sample Bag" on page 83 for instructions to properly use a gas bag kit.***

To calibrate the %LEL, oxygen, CO, and H_2S sensors at the same time, automatically, with no need for a zero-oxygen source, you can use the auto calibration feature with a 4-gas cylinder. If the H_2S channel is not active, then a 3-gas cylinder may be used for auto calibration. This chapter includes instructions for auto calibration with a demand-flow regulator and a 4-gas cylinder. This chapter also includes instructions for calibrating one channel at a time using single calibration.

Entering Calibration Mode

To enter Calibration Mode, do the following:

1. Find a fresh-air environment. This is an environment free of toxic or combustible gases and of normal oxygen content (20.9%).
2. While in Measuring Mode, press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both buttons.

3. If the unit prompts you for the password, enter it by using the AIR ▲ YES and RANGE ▼ SHIFT buttons to select each password number and then pressing and releasing POWER ENTER RESET to enter the number and move on to the next one.
4. The Calibration Mode Screen displays with the cursor next to **AUTO CALIBRATION**.

```
CALIBRATION MODE

> AUTO CALIBRATION
  SINGLE CALIBRATION
  PERFORM AIR ADJUST
  NORMAL OPERATION
```

NOTE: The following screens illustrate a four-gas EAGLE 2 for detection of CH_4 (%LEL using catalytic sensor), oxygen, H_2S, and CO. Your EAGLE 2 may display slightly different screens.

Calibrating Using the Auto Calibration Method

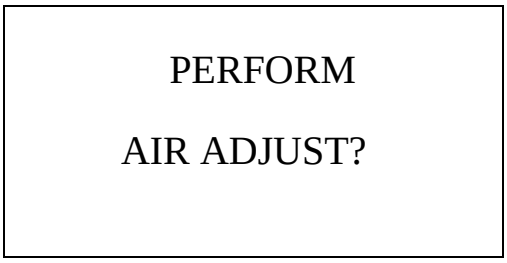
This method allows you to calibrate the CH_4 (%LEL sensor), oxygen, H_2S, and CO sensors simultaneously. It is designed for use with the RKI 4-gas calibration cylinder and is the quickest and easiest method to calibrate the EAGLE 2.

Setting the Fresh Air Reading

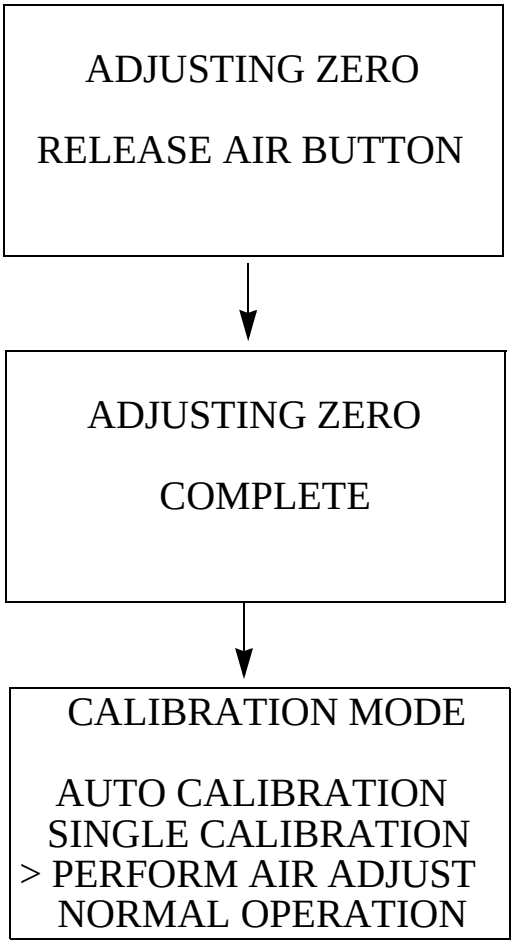
1. While in the Calibration Mode Screen, move the cursor to the **PERFORM AIR ADJUST** menu item by using the RANGE ▼ SHIFT button.

```
CALIBRATION MODE

  AUTO CALIBRATION
  SINGLE CALIBRATION
> PERFORM AIR ADJUST
  NORMAL OPERATION
```

2. Press and release the POWER ENTER RESET button. The following screen appears.

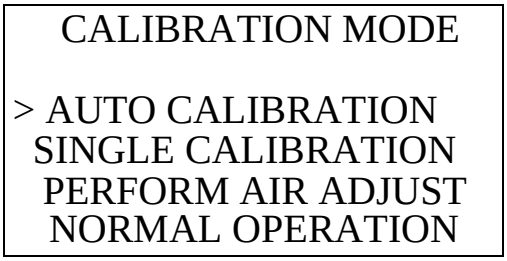


3. Press and release the AIR ▲ YES button to continue.
   If you do not want to continue, press the DISPLAY ADJUST NO button and the unit will return to the Calibration Mode Screen.
4. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.

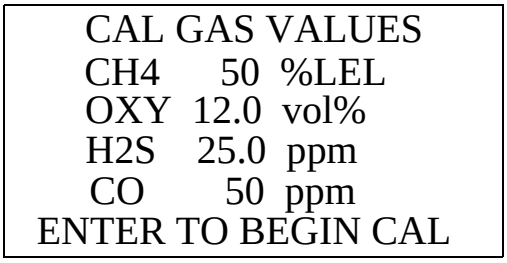


Performing a Span Adjustment in Auto Calibration

1. Install the demand flow regulator onto the calibration cylinder.
2. Connect the sample tubing to the demand flow regulator.
3. Install the probe on the EAGLE 2 inlet fitting. Make sure the probe is complete with internal O-ring and membrane and that the two halves of the probe are tightened firmly together to avoid leaks that can affect the calibration. See Figure 20, “Replacing the Hydrophobic Filter Disk & O-ring” on page 73 for an illustration of the internal parts of the probe.
4. Move the cursor next to the **AUTO CALIBRATION** menu item by using the AIR ▲ YES button.



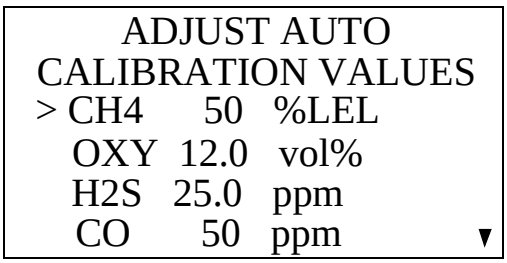
5. Press and release the POWER ENTER RESET button to display the Calibration Gas Values Screen.



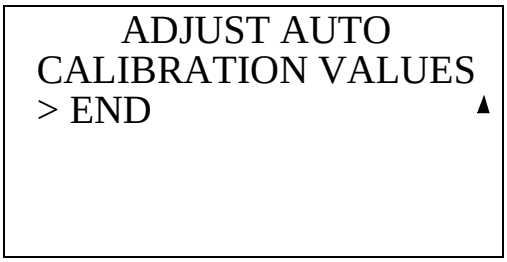
The gas concentrations displayed in the Calibration Gas Values Screen must match the gas concentrations listed on the 4-gas calibration cylinder.
If *all* concentrations match, go to Step 16.
If *one or more* concentrations *do not* match, continue with Step 6.
If you do not want to continue with the calibration, press and release the DISPLAY ADJUST NO button to return to the Calibration Mode Screen.

NOTE: The RKI 4-gas cylinder typically contains 12% O_2 by volume. When using the auto calibration method, be sure to set the “OXY” auto calibration value to agree with the concentration listed on the cylinder’s label, not zero.

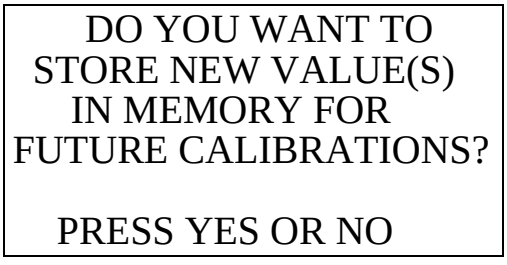
6. To adjust the values on the screen, press and hold the RANGE ▼SHIFT button, then press the DISPLAY ADJUST NO button and release both. The following screen appears with the cursor next to **CH4**.



7. Place the cursor next to the channel whose gas value you want to change using the AIR ▲ YES and RANGE ▼SHIFT buttons.
8. Press and release the POWER ENTER RESET button to select the channel. The calibration gas value begins to flash.
9. Use the AIR ▲ YES and RANGE ▼SHIFT buttons to adjust the calibration gas setting to the desired value.
10. Press and release the POWER ENTER RESET button to save the change. The calibration gas value stops flashing.
11. Repeat Step 7 through Step 10 for any other channels that need to be changed.
12. When you are done adjusting the calibration gas values, move the cursor down past the bottom of the screen next to **END**.



13. Press and release the POWER ENTER RESET button. The following screen appears.

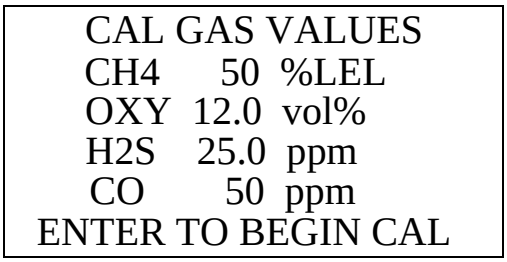


14. If you select YES by pressing and releasing the AIR ▲ YES button, the changes that you made will be saved in the EAGLE 2's memory as the

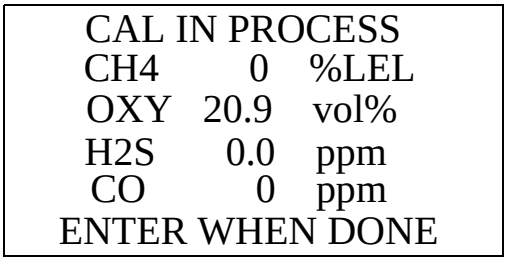
new auto calibration gas values.

If you select NO by pressing and releasing the DISPLAY ADJUST NO button, the changes you made will be used for any calibrations performed during the current operating session only. The EAGLE 2 will delete the changes when the unit is turned off and will load the previous set of auto calibration values when it is turned on again.

15. When you make your selection and press the desired button, the unit returns to the Calibration Gas Values Screen.



16. Press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen with **CAL IN PROCESS** flashing.

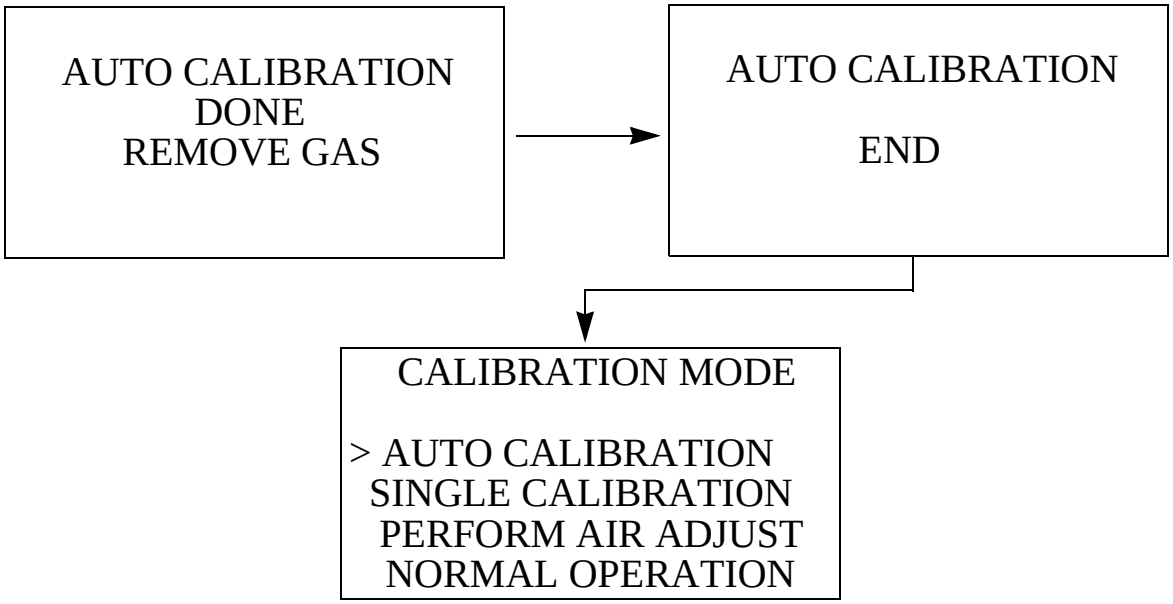


If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the Cal Gas Values Screen.

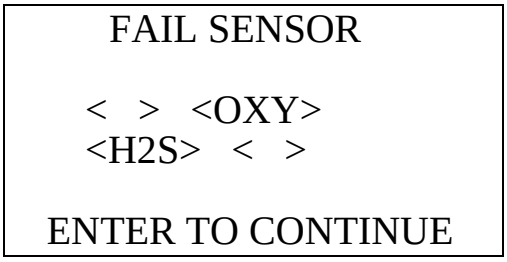
If you do want to continue with the calibration, proceed to the next step.

17. Connect the tubing from the demand flow regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for one minute.
18. Press and release the POWER ENTER RESET button to set the span adjustment for each channel to the programmed values.

19. If all channels passed calibration, the following screen sequence occurs.



If any of the sensors cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and lists the sensor(s) that failed to calibrate. In the example below, the oxygen and H_2S channels failed calibration. The other sensors calibrated normally.



The buzzer and alarm LED arrays activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and return to the Calibration Mode Screen. Attempt to calibrate again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

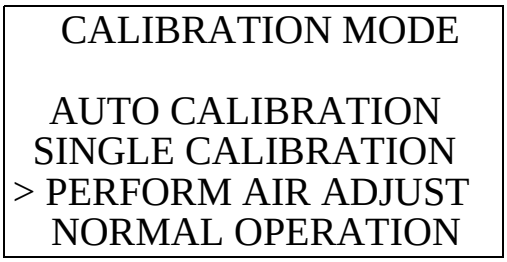
20. Disconnect the tubing from the probe.
21. Unscrew the demand flow regulator from the calibration cylinder.
22. Use the RANGE ▼SHIFT button to place the cursor next to the **NORMAL OPERATION** menu option, then press and release the POWER ENTER RESET button to return to Measuring Mode.

Calibrating Using the Single Calibration Method

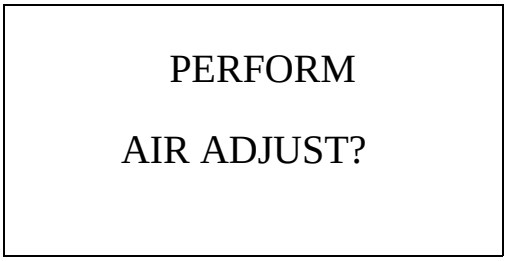
Single Calibration allows you to calibrate one channel at a time. This is useful if you only want to calibrate one or two channels.

Setting the Fresh Air Reading

1. While in the Calibration Mode Screen, move the cursor to the **PERFORM AIR ADJUST** menu item by using the RANGE ▼ SHIFT button.



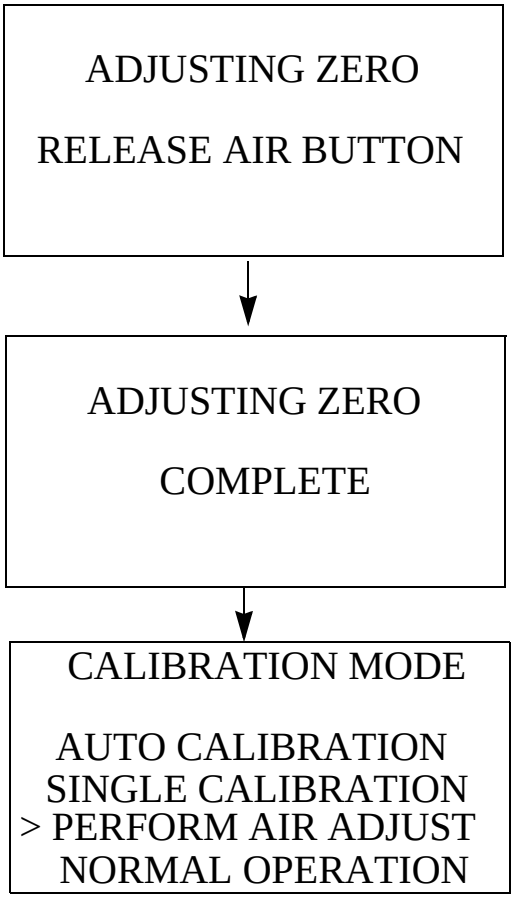
2. Press and release the POWER ENTER RESET button. The following screen appears.



3. Press and release the AIR ▲ YES button to continue.

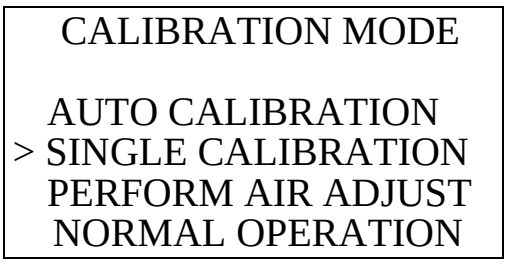
   If you do not want to continue, press the DISPLAY ADJUST NO button and the unit will return to the Calibration Mode Screen.

4. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.

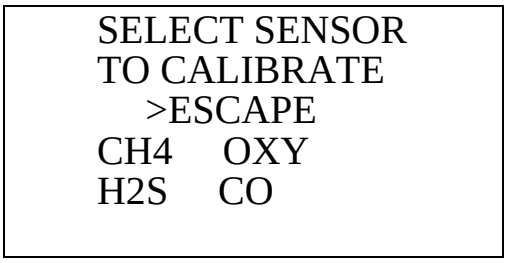


Performing a Span Adjustment in Single Calibration

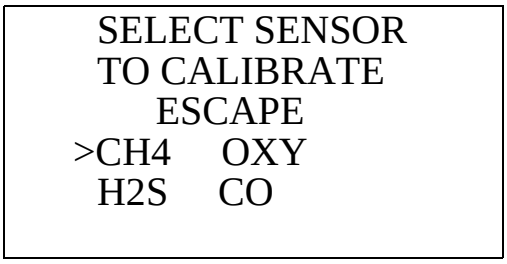
1. Install the demand flow regulator onto the calibration cylinder.
2. Connect the sample tubing to the demand flow regulator.
3. Install the probe on the EAGLE 2 inlet fitting. Make sure the probe is complete with internal O-ring and membrane and that the two halves of the probe are tightened firmly together to avoid leaks that can affect the calibration. See Figure 20, “Replacing the Hydrophobic Filter Disk & O-ring” on page 73 for an illustration of the internal parts of the probe.
4. Move the cursor next to the **SINGLE CALIBRATION** menu item by using the AIR ▲ YES button.



5. Press and release the POWER ENTER RESET button. The Select Sensor Screen appears with the cursor flashing.



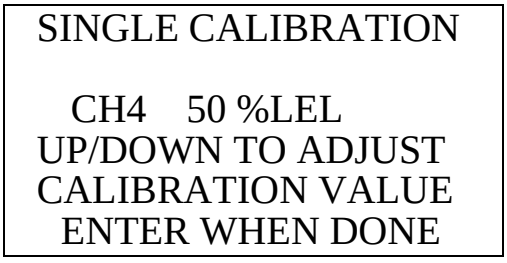
6. Move the cursor next to the sensor you want to calibrate with the AIR ▲ YES and RANGE ▼ SHIFT buttons. In the example below, the CH_4 sensor is selected for span adjustment.



If you do not want to proceed with the span adjustment, press and release the DISPLAY ADJUST NO button or place the cursor next to **ESCAPE** and press and release POWER ENTER RESET to return to the Calibration Mode Screen.

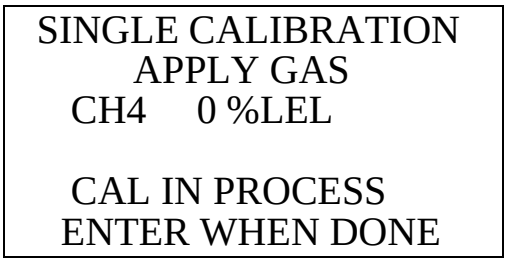
To proceed with the calibration, continue with the next step.

7. Press and release the POWER ENTER RESET button to proceed to the Single Calibration Gas Value Screen for the selected channel. The calibration gas value is flashing.

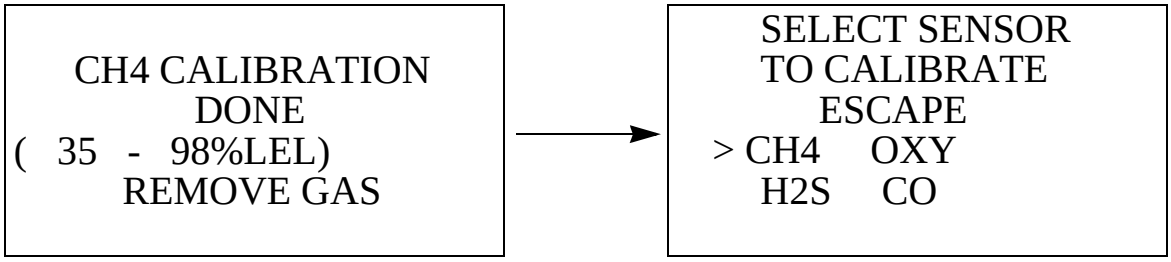


8. If necessary, adjust the calibration gas value to match the cylinder concentration with the AIR ▲ YES and RANGE ▼ SHIFT buttons.

9. Press and release the POWER ENTER RESET button to proceed to the Single Calibration Apply Gas Screen. **CAL IN PROCESS** is flashing.

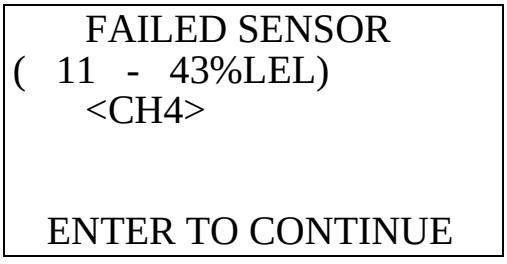


10. Connect the tubing from the demand flow regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for one minute.
11. Press and release the POWER ENTER RESET button to perform the calibration.
12. When the span adjustment is made, the EAGLE 2 calculates the range of adjustment, minimum and maximum, it could have made based on its response level to the applied gas. This calculated range is independent of the calibration gas value that was entered in Step 8 and Step 9 above. The adjustment range is included on the result screen to indicate the condition of the sensor. If the calibration gas value is in the adjustment range, the span adjustment will pass. If the calibration gas value is out of the adjustment range, the span adjustment will fail.
13. If the span adjustment is successful, the following screens display.



In the example above, the EAGLE 2 could have adjusted the reading as low as 35 %LEL and as high as 98 %LEL.

If the span adjustment is not successful, a screen displays that indicates a calibration failure.



In the example above, the EAGLE 2 could have adjusted the reading as

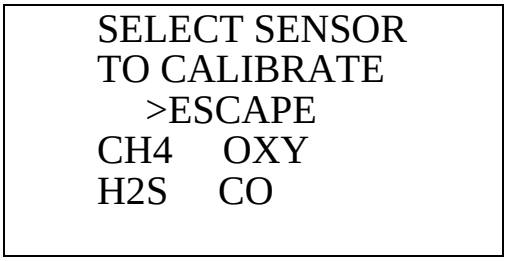
low as 11 %LEL and as high as 43 %LEL. Since the calibration gas value entered was 50 %LEL, the unit failed the span adjustment. The buzzer and alarm LED arrays activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and return to the Select Sensor Screen. Attempt to calibrate again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

NOTE: The adjustment range will only appear in the calibration results screen if the Span Factor item in Setup Mode is set to ON. If the Span Factor is set to OFF, the adjustment range will not appear.

14. Disconnect the tubing from the EAGLE 2’s probe.
15. Repeat Step 6 through Step 14 for any other channels you want to calibrate. Make sure you use an appropriate calibration cylinder for each sensor.

CAUTION: *When calibrating the oxygen sensor, verify the concentration of oxygen listed on the cylinder’s label. For oxygen-free samples (100% nitrogen for example), set the oxygen calibration value to 0.0%.*

16. After the last channel is calibrated, disconnect the calibration tubing from the probe, then unscrew the demand flow regulator from the calibration cylinder.
17. With the Select Sensor Screen displayed, place the cursor next to **ESCAPE** using the AIR ▲ YES button.



18. Press and release the POWER ENTER RESET button to return to the Calibration Mode Screen.
19. Use the RANGE ▼ SHIFT button to place the cursor next to the **NORMAL OPERATION** menu item, then press and release the POWER ENTER RESET button to return to Measuring Mode.

Chapter 5: Maintenance

Overview

This chapter describes troubleshooting procedures for the EAGLE 2. It also includes procedures for replacing and recharging the batteries and replacing various consumable parts.

WARNING: ***RKI Instruments, Inc. recommends that service, calibration, and repair of RKI instruments be performed by personnel properly trained for this work. Replacing sensors and other parts with original equipment does not affect the intrinsic safety of the instrument.***

Troubleshooting

The troubleshooting table describes error messages, symptoms, probable causes, and recommended action for problems you may encounter with the EAGLE 2.

Table 9: Troubleshooting the EAGLE 2

Symptoms	Probable Causes	Recommended Action
• The LCD is blank.	• The unit may have been turned off. • The alkaline batteries may need to be replaced or the Ni-MH batteries recharged.	1. To turn on the unit, press and briefly hold the POWER ENTER RESET button. 2. If the unit does not turn on, replace the alkaline batteries or recharge the Ni-MH batteries. 3. If the difficulties continue, contact RKI Instruments, Inc. for further instruction.
• The LCD shows abnormally high or low readings but other gas detection instruments do not.	• The EAGLE 2 may need to be recalibrated. • The sensor for the affected channel(s) may need replacement.	1. Recalibrate the unit. 2. If the difficulties continue, replace the sensor for the affected channel(s) and calibrate the affected channel(s). 3. If the difficulties continue, contact RKI Instruments, Inc. for further instruction.

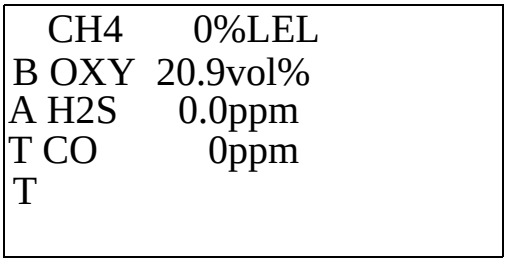
Table 9: Troubleshooting the EAGLE 2

Symptoms	Probable Causes	Recommended Action
• The unit indicates flow failure and does not recover when POWER ENTER RESET is pressed and released.	• The probe tube is clogged. • The hydrophobic filter disk in the probe is dirty. • The sample hose has a kink or obstruction. • The internal hydrophobic filter is dirty. • The pump is malfunctioning.	1. Inspect the probe tube for any obstructions. 2. Inspect the hydrophobic filter disk in the probe and replace if necessary. 3. Inspect the sample hose for kinks or obstructions and replace if necessary. 4. Inspect the internal hydrophobic filter and replace if necessary. 5. If difficulties continue, contact RKI Instruments, Inc. for further instruction.
• Auto calibration or single calibration fails.	• The auto calibration values may not match the cylinder gas concentrations (auto calibration only). • The charcoal filter is saturated causing an elevated CO reading. • The sample gas is not reaching the sensors because of a bad connection. • The calibration cylinder may be out of gas or is outdated. • The sensor for the affected channel(s) may need replacement.	1. Check all calibration tubing for leaks or for any bad connections. 2. Make sure the EAGLE 2 has been properly set up for calibration. 3. Change the charcoal filter. 4. Verify that the calibration cylinder contains an adequate supply of fresh test sample. 5. If the fail condition continues, replace the sensor(s). 6. If the difficulties continue, contact RKI Instruments, Inc. for further instruction.
• Display indicates “SYSTEM FAIL 12” during startup.	• A memory error has occurred.	1. Press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both. The Enter Password Screen will appear. 2. Enter the password, “1994”, to proceed to the Set Default Screen. 3. Press and release the AIR ▲ YES button twice to restore the defaults. See “Restoring the Default Settings” on page 124 for a description of issues to consider when restoring the defaults. 4. If difficulties continue, contact RKI Instruments, Inc. for further instruction.

Replacing or Recharging the Batteries

WARNING: To prevent ignition of a hazardous atmosphere, batteries must only be changed or charged in an area known to be nonhazardous.

Replace or charge the batteries when the EAGLE 2 indicates that it is in low battery warning. When in low battery warning, BATT appears vertically along the left side the LCD.



Replacing the Batteries

NOTE: Use Duracell Procell PC 1400 alkaline batteries, Duracell MN 1400 alkaline batteries, Energizer E93 or Energizer EN93, or RKI Instruments, Inc. 49-1330RK Ni-MH batteries to maintain the CSA classification of the EAGLE 2. Use of other batteries or mixing alkaline and rechargeable batteries will void the CSA classification and may void the warranty.

1. Turn off the EAGLE 2.

WARNING: Do not remove the batteries while the EAGLE 2 is on.

2. Loosen the battery case thumbscrew by turning it counterclockwise until it disengages from the bottom case. If necessary, use a coin or large flat blade screwdriver to loosen it.

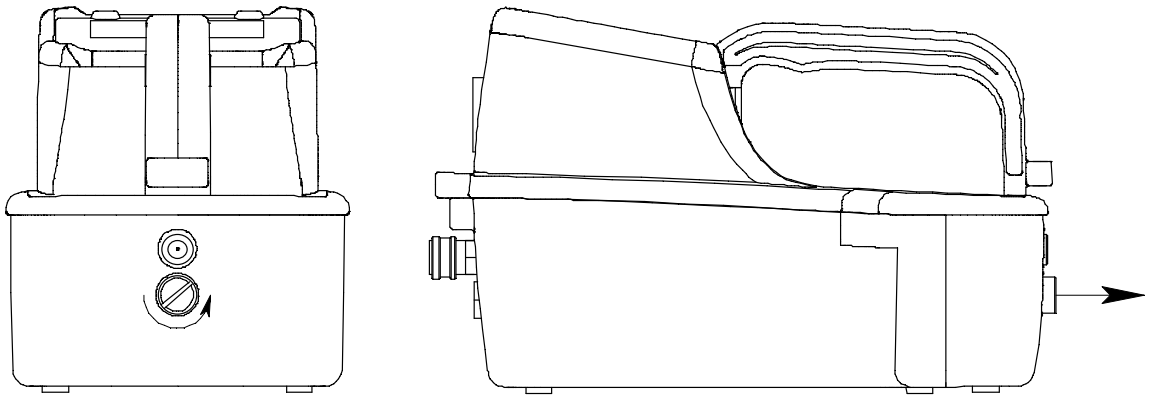


Figure 17: Removing the Battery Case

3. Pull the battery case away from the bottom case. The thumbscrew is captive and will not fall out.
4. Carefully remove the old batteries. Verify that the battery compartment and electrical contacts are clean.
5. Carefully install the new C-size batteries. Follow the battery diagram inside the battery case. Make sure the batteries are pushed in all the way.

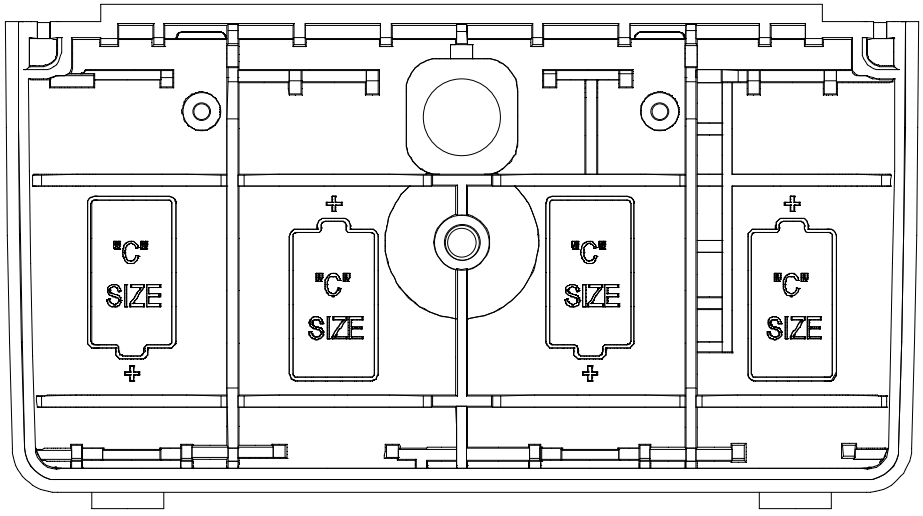


Figure 18: Installing the Batteries

6. Reinstall the battery case onto the bottom case tightening the thumbscrew firmly by hand so that there is no visible gap between the battery case and the bottom case.

Recharging the Ni-MH Batteries

CAUTION: *Use with Ni-MH battery p/n 49-1330RK. Charge only with RKI charger model 49-2175RK, 49-2176RK, or 49-2177RK. Use of other rechargeable batteries or chargers or charging of other rechargeable batteries in the EAGLE 2 will void the warranty.*

The charging module can either be used with an AC adapter or a vehicle plug DC adapter. Both adapters plug into the module which then plugs into the EAGLE 2.

1. Plug the power adapter into either an AC outlet or into a vehicle outlet depending on which charger is being used.
2. Make sure the switch on the module is set to “BATT. CHARGER”.
3. Make sure the EAGLE 2 is off.
4. Make sure the adapter and module are connected.
5. Insert the module’s round plug into the EAGLE 2’s charging jack as shown in Figure 19 below.

NOTE: The battery pack does not need to be attached to the EAGLE 2 case in order to charge. It may be charged separately. This allows a spare battery pack to be charged while the EAGLE 2 is in use.

Figure 19: Connecting the EAGLE 2 to the Charger

6. While the batteries are charging, the green indicator LED will be off and the amber one will be on.
7. The charging module has an internal timeout feature set at 9.5 hours. A full charge should be reached in less than 9.5 hours. When a full charge has been reached, both the green and yellow LEDs will be on.
8. If charging should fail, the green indicator LED will be off and the amber one will be blinking.

Table 10 summarizes the battery charger conditions.

Table 10: Battery Charger Conditions

Amber LED	Green LED	Status
ON	OFF	CHARGING
ON	ON	READY/FULL
BLINKING	OFF	FAIL
OFF	ON	CONTINUOUS OPERATION

Replacing the Hydrophobic Probe's Filter Disk & O-ring

Inspect the probe's internal components if you notice that the EAGLE 2's pump sounds bogged down or if an unexplained low flow alarm occurs. Replace the hydrophobic filter disk if it appears dirty or saturated with liquid. Replace the O-ring if it appears damaged.

1. Grasp each end of the white probe body firmly and unscrew the two halves from each other. One half includes a plastic tube fitting and the probe tube. The other half includes a metal fitting that mates with the EAGLE 2 inlet fitting and a stainless steel support screen for the filter disk.

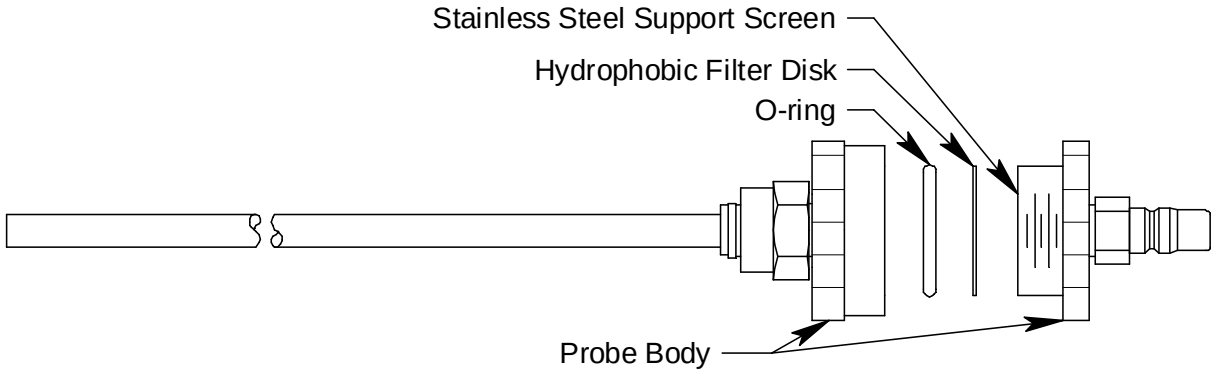


Figure 20: Replacing the Hydrophobic Filter Disk & O-ring

2. Remove the O-ring if it sticks in either half of the probe body.
3. Remove the white hydrophobic filter disk from the support screen.
4. Clean the inside of the probe body if necessary.
5. Hold the probe half that has the support screen with the screen facing up.
6. Place the new filter disk flat on the support screen. Make sure it is centered over the screen.
7. Place the O-ring (or replacement O-ring) on the filter disk. Make sure the O-ring is centered over the disk.
8. Carefully screw the other half of the probe body onto the half with the disk and O-ring while keeping the probe oriented vertically to keep the disk and O-ring centered.
9. When you feel the O-ring being compressed, grasp both ends of the probe and tighten them together very firmly to ensure a seal.
10. To test the seal, do the following.
    - install the probe on the EAGLE 2
    - startup the EAGLE 2
    - confirm that a low flow alarm occurs when you cover the end of the probe tube with your finger
    - if a low flow alarm does not occur, hand tighten the probe further
    - if a low flow alarm still does not occur when you cover the probe tube with your finger, disassemble the probe, inspect the placement of the O-ring and filter disk, reassemble the probe and re-test it.

Replacing the Hydrophobic Filter

Replace the hydrophobic filter inside the bottom case when it becomes dirty or clogged. An unexplained low flow alarm may indicate that the hydrophobic filter is dirty and needs to be replaced.

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main PCB with the cable that connects the top case to the main PCB.

5. Lay the top case down next to the bottom case to allow access to the flow system.
6. Locate the hydrophobic filter. It is over the oxygen sensor. Note which side of the hydrophobic filter has the RKI logo and part number. This is the inlet side and should be facing toward the front of the EAGLE 2.

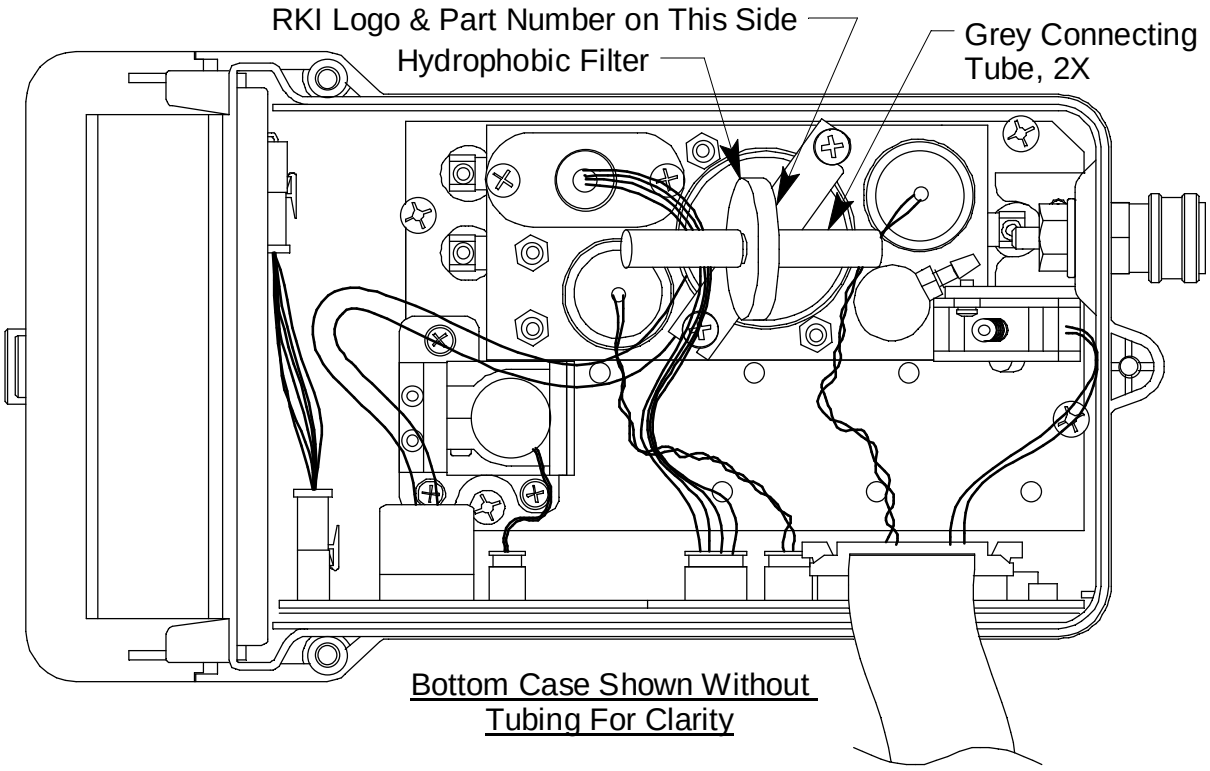


Figure 21: Replacing the Hydrophobic Filter

7. Pull the grey connecting tubes off of each end of the filter and remove it.
8. Install the new filter with the red RKI logo and part number on the inlet side of the flow chamber, facing the front of the EAGLE 2. Make sure to push the grey connection tubes all the way onto the filter's hose barbs.
9. Confirm that the main PCB is seated in its slots and that its bottom edge is resting on the bottom of the bottom case. If the main PCB is not seated properly, then it may be damaged when the top case is re-installed.
10. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
11. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.

Replacing the Charcoal Filter

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main PCB with the cable that connects the top case to the main PCB.
5. Lay the top case down next to the bottom case to allow access to the flow system.
6. Locate the charcoal filter. It is next to the CO sensor at the front of the flow chamber.

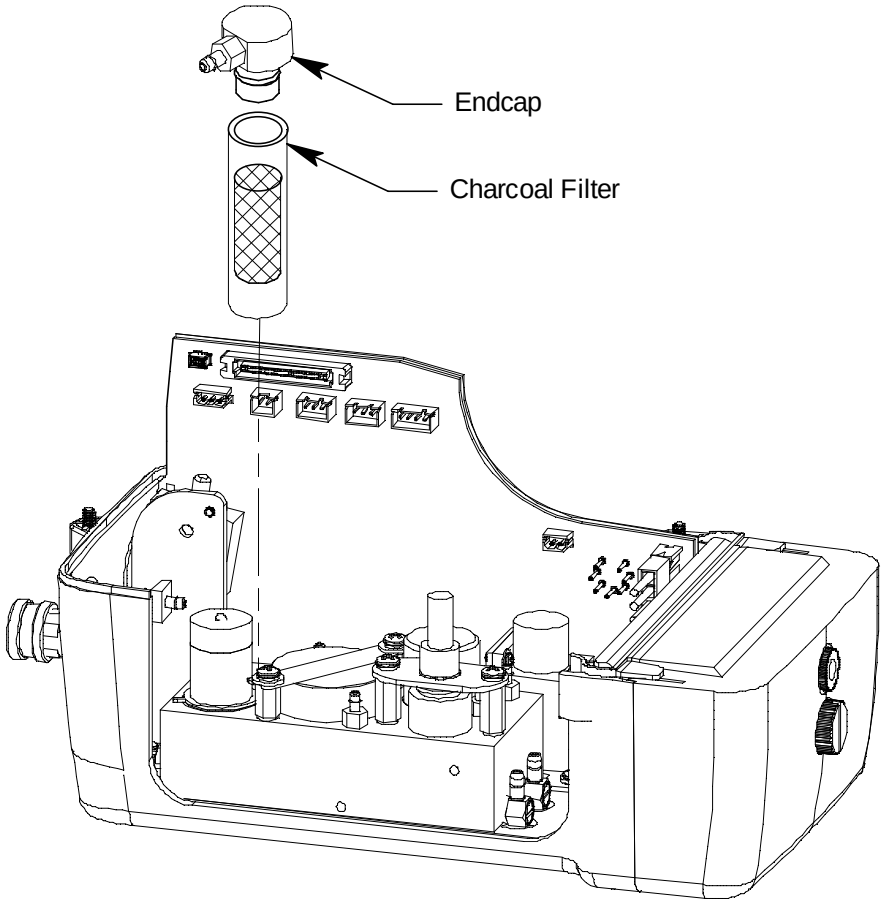


Figure 22: Replacing the Charcoal Filter

7. Grasp the black charcoal filter endcap and pull it off of the charcoal filter.
8. Grasp the top of the charcoal filter firmly and pull it out of the flow chamber.

Insert the replacement charcoal filter into the filter position in the flow chamber and push it in until it bottoms out.

9. Insert the charcoal filter endcap into the end of the charcoal filter and push it in until it bottoms out.
10. Confirm that the main PCB is seated in its slots and that its bottom edge is resting on the bottom of the bottom case. If the main PCB is not seated properly, then it may be damaged when the top case is re-installed.
11. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
12. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.

Checking the Combustible Gas Sensor's Condition

If you suspect that the combustible sensor has been contaminated or may be reaching the end of its operational life, do the following to confirm it is still operating properly:

1. Perform a calibration using single calibration as described in "Calibrating Using the Single Calibration Method" on page 63.
2. When you perform the span adjustment, note the adjustment range on the result screen as described in Step 12 and Step 13 on page 66.
3. A new sensor can typically be adjusted to more than twice the calibration gas concentration. If the result screen indicates that the EAGLE 2 could not adjust the combustible gas reading to be at least 10% higher than the calibration gas concentration, then the sensor should be replaced as soon as possible.

Replacing a Sensor

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main

PCB with the cable that connects the top case to the main PCB.

5. Lay the top case down next to the bottom case to allow access to the flow system.
6. Locate the sensor you want to replace and remove it from the flow chamber.

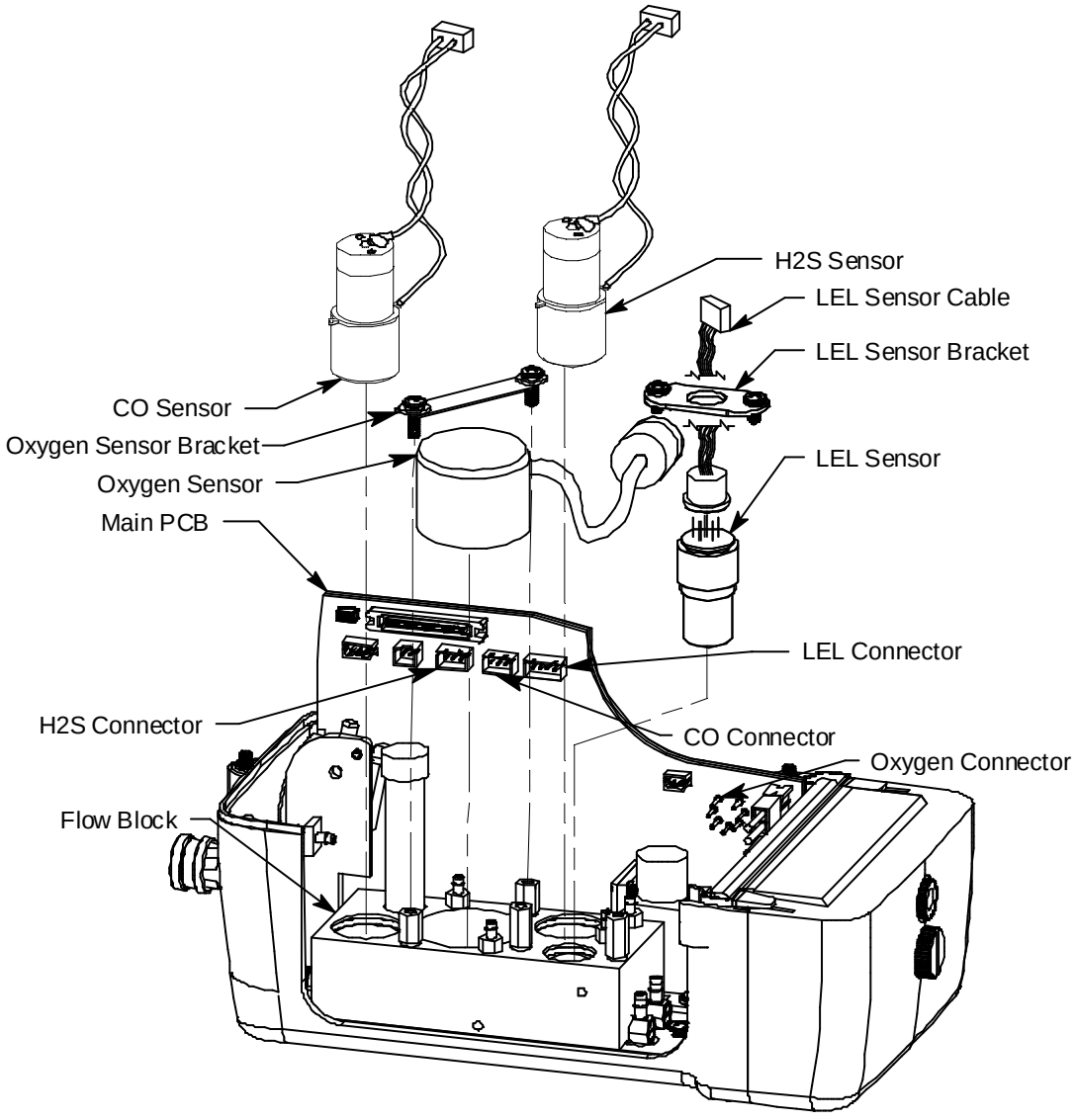


Figure 23: Replacing a Sensor

7. To remove the LEL sensor, do the following:
   - Unscrew and remove the two screws that hold down the LEL sensor bracket.
   - Grasp the LEL sensor connector and gently pull it up until it either disengages from the LEL sensor or the LEL sensor comes out of the flow chamber with the connector.
   - If the sensor came out with the connector, remove the sensor from the

connector.

- If the sensor stayed in the flow chamber, grasp the sensor and pull it out of the flow chamber.

8. To remove the oxygen sensor, do the following:
   - Unscrew the two screws that hold the oxygen sensor bracket a few turns so that you can rotate and remove the oxygen sensor bracket. Make sure to note the routing of the oxygen sensor cable to the main PCB so that you can route the replacement sensor cable the same way. Also make sure that the O-ring in the bottom of the flow chamber does not come out with the sensor.
   - Move the hydrophobic filter towards the bottom case side wall and pull the oxygen sensor out of the flow chamber.
   - Hold the main PCB to support it where the oxygen sensor cable connects to it.
   - Grasp the connector on the end of the sensor cable and pull the connector away from the main PCB to disconnect it from the main PCB.
9. To remove the H_2S and CO sensors, do the following:
   - Grasp the sensor firmly and rock it back and forth slightly while pulling on it. Make sure to note the routing of the sensor cable to the main PCB so that you can route the replacement sensor cable the same way.
   - If the sensor does not come out of the flow chamber easily enough using this method, grasp it with a pair of pliers and rock it back and forth slightly while pulling on it.

CAUTION: *If using pliers to remove a sensor, be careful not to damage the sensor in case you find that the sensor is still functional and does not need to be replaced.*

   - Hold the main PCB to support it where the sensor cable connects to it.
   - Grasp the connector on the end of the sensor cable and pull the connector away from the main PCB to disconnect it from the main PCB.
10. Install the new sensor.
11. To install the LEL sensor, do the following:
    - Plug the replacement sensor into the sensor connector on the LEL

sensor cable.

- Insert the LEL sensor into the LEL sensor chamber in the flow chamber.
- Line up the holes in the LEL sensor bracket with the two standoffs on either side of the LEL sensor chamber.
- Install the two sensor bracket screws tightening them a little at a time alternately to push the sensor into its chamber evenly.

12. To install the oxygen sensor, do the following:
    - Confirm that the sealing O-ring is still in the bottom of the oxygen sensor chamber in the flow chamber and insert the oxygen sensor face down into the chamber.
    - Route the sensor cable the same way the old sensor cable was routed and connect it to the main PCB. Make sure to support the main PCB when making the connection.
    - Reinstall the oxygen sensor bracket and tighten both bracket screws firmly.
13. To install the H_2S and CO sensors, do the following:
    - Insert the sensor face down into the sensor chamber in the flow chamber.
    - Push the sensor in until it bottoms out.
    - Route the sensor cable the same way the old sensor cable was routed and connect it to the main PCB. Make sure to support the main PCB when making the connection.
14. Confirm that the main PCB is seated in its slots and that its bottom edge is resting on the bottom of the bottom case. If the main PCB is not seated properly, then it may be damaged when the top case is re-installed.
15. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
16. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.
17. Calibrate the new sensors as described in “Chapter 4: Calibration Mode” on page 55.

General Parts List

Table 11 lists part numbers for the EAGLE 2's replacement parts and accessories.

Table 11: General Parts List

Part Number	Description
06-1248RK-03	Calibration kit tubing,3 foot length
07-6020RK	O-ring for probe
13-1061RK	Panel screw, captive, 6-32 x 1/2 inch, for bottom case
13-1081RK	Thumbscrew, captive, 10-32 x 2 inches, for battery case
30-0600RK-01	Pump
33-0156RK-01	Filter element, hydrophobic disk, for standard 80-0131RK probe, pack of 5
33-0173RK	Internal hydrophobic filter
33-6090RK	Charcoal filter
35-0110RK	Dummy sensor, CO or H_2S sensor position
35-0111RK	Dummy sensor, oxygen sensor position
35-0112RK	Dummy sensor, LEL sensor position
47-1016RK	Vehicle plug 12 VDC adapter cable for charger
47-5010RK	TC/LEL sensor cable
47-5027RK	Downloading cable, USB/IrDA adapter
49-0115RK	AC adapter
49-1130RK	C size alkaline battery
49-1330RK	C size Ni-MH battery
49-2174RK	Charging module
49-2175RK	115/220 VAC charger
49-2176RK	12 VDC charger
49-2177RK	115/220 VAC and 12 VDC charger
65-0601RK	Oxygen sensor
65-2005RK	Carbon monoxide (CO) sensor
71-0154RK	Operator's Manual, EAGLE 2 (this document)
71-0170RK	Operator's Manual, Eagle 2 Data Logger Management Program

Table 11: General Parts List (cont.)

Part Number	Description
71-8003RK	EAGLE 2 Product CD, includes Data Management Program, User Setup Program, and all operator's manuals
80-0131RK	10 inch hydrophobic probe (standard probe)
80-0133RK	30 inch aluminum probe
80-0134RK	4 foot stainless steel hydrophobic probe
80-0135RK	30 inch stainless steel hydrophobic probe
80-0136RK	32 inch telescoping fiberglass probe w/dust filter
80-0137RK	10 inch probe w/dust filter
80-0143RK	7 foot telescoping fiberglass probe w/dust filter
80-0156RK	30 inch fiberglass hydrophobic probe
80-0160RK-12	12 foot extendible probe
80-0160RK-18	18 foot extendible probe
80-0405RK	Dilution fitting, 1:1
80-0406RK	Dilution fitting, 3:1
80-05XXRK	Sample hose. Replace "XX" with length in feet. 5 foot hose is standard. Available lengths for the EAGLE 2 are 3, 4, 5, 6, 10, 15, 20, 25, 30, 35, 40, 50, 75, 100, and 125 feet.
81-0090RK-01	Calibration cylinder, steel, 34 liter, three-gas ($CH_4/O_2/CO$)
81-0090RK-03	Calibration cylinder, steel, 103 liter, three-gas ($CH_4/O_2/CO$)
81-0154RK-02	Calibration cylinder, aluminum, 58 liter; four-gas ($CH_4/O_2/ H_2S/CO$)
81-0154RK-04	Calibration cylinder, aluminum, 34 liter; four-gas ($CH_4/O_2/ H_2S/CO$)
81-1054RK	Regulator, demand-flow type (for 58- and 103-liter aluminum or steel, and 34-liter aluminum calibration cylinders)
81-5302RK	Calibration kit, for LEL/Oxy/CO unit, w/demand flow regulator, 103 liter cylinder
81-5401RK	Calibration kit, for LEL/Oxy/H_2S/CO unit, w/demand flow regulator, 58 liter cylinder
ES-87RW-H2S	Hydrogen Sulfide (H_2S) sensor
NC-6260B	LEL combustible sensor, catalytic

Appendix A: Calibrating with a Sample Bag

Overview

The EAGLE 2 can be calibrated with a gas bag calibration kit instead of a demand flow regulator kit. This appendix describes how to use a sample bag calibration kit to calibrate the EAGLE 2. A parts list at the end of this appendix lists spare parts for the calibration kit.

Calibration Supplies and Equipment

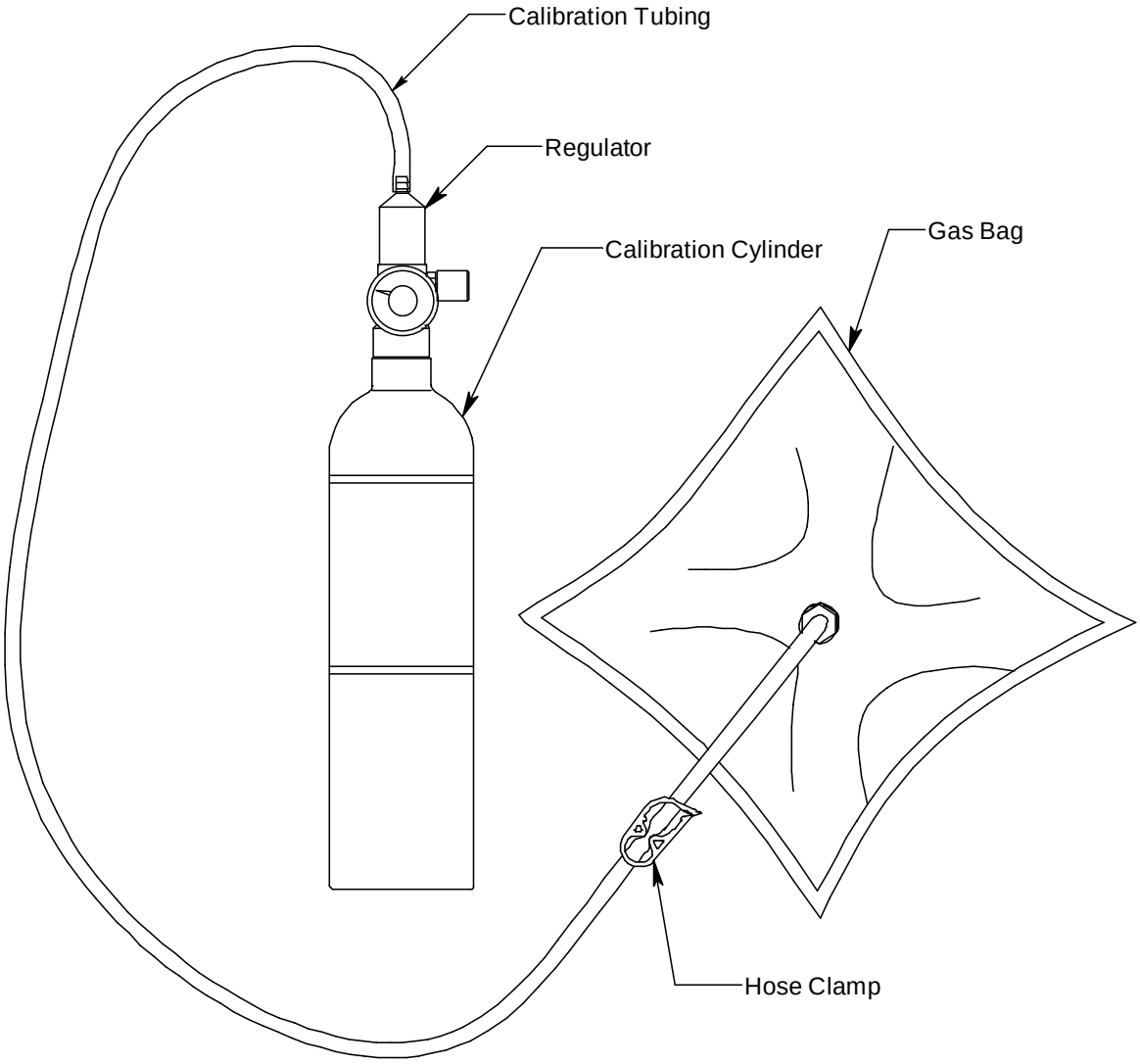


Figure 24: Gas Bag Calibration Kit

To calibrate the EAGLE 2, you will need:

- Known calibrating samples of the gases being detected. The combustible and toxic gas samples should have concentrations in approximately the middle of the range of detection. An oxygen-free source, such as 100% nitrogen is recommended for setting the oxygen zero when using single calibration.

CAUTION: *When using auto calibration with the standard 4-gas EAGLE 2, although the EAGLE 2 can be calibrated with an oxygen concentration of up to 19.5%, RKI Instruments, Inc. recommends that the multi-gas cylinder have an oxygen concentration in the range of 10% - 16% oxygen.*

- A gas collection bag with hose clamp
- A 6 LPM fixed-flow regulator or a dispensing valve
- Calibration tubing

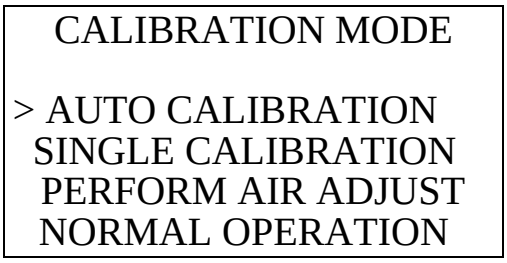
To calibrate the combustible gas, oxygen, CO, and H_2S sensors at the same time, automatically, with no need for a zero-oxygen source, you can use the auto calibration feature with a 4-gas cylinder. If the H_2S channel is not active, then a 3-gas cylinder may be used for auto calibration. This document includes instructions for auto calibration with a fixed flow regulator or dispensing valve, a sample bag, and a 4-gas cylinder. This document also includes instructions for calibrating one channel at a time using single calibration.

Entering Calibration Mode

To enter Calibration Mode, do the following:

1. Find a fresh-air environment. This is an environment free of toxic or combustible gases and of normal oxygen content (20.9%).
2. While in Measuring Mode, press and hold the RANGE ▼SHIFT button, then press the DISPLAY ADJUST NO button and release both buttons.
3. If the unit prompts you for the password, enter it by using the AIR ▲ YES and RANGE ▼SHIFT buttons to select each password number and then pressing and releasing POWER ENTER RESET to enter the number and move on to the next one.

4. The Calibration Mode Screen displays with the cursor next to **AUTO CALIBRATION**.



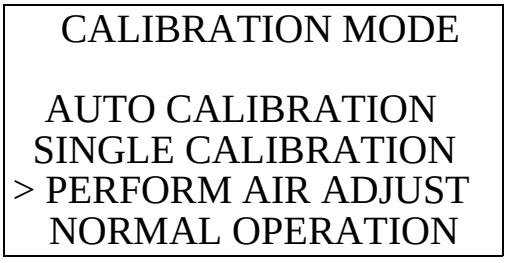
NOTE: The following screens illustrate a 4-gas EAGLE 2 for detection of CH_4 (%LEL using catalytic sensor), oxygen, H_2S, and CO. Your EAGLE 2 may display slightly different screens.

Calibrating Using the Auto Calibration Method

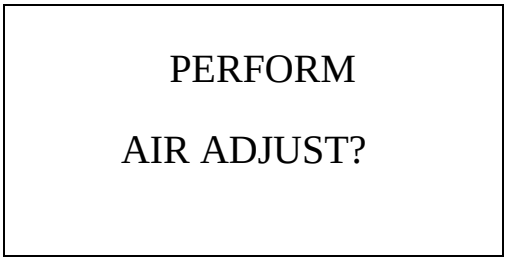
This method allows you to calibrate the CH_4 (%LEL catalytic combustible sensor), oxygen, H_2S, and CO sensors simultaneously. It is designed for use with the RKI 4-gas calibration cylinder and is the quickest and most convenient method to calibrate the EAGLE 2.

Setting the Fresh Air Reading

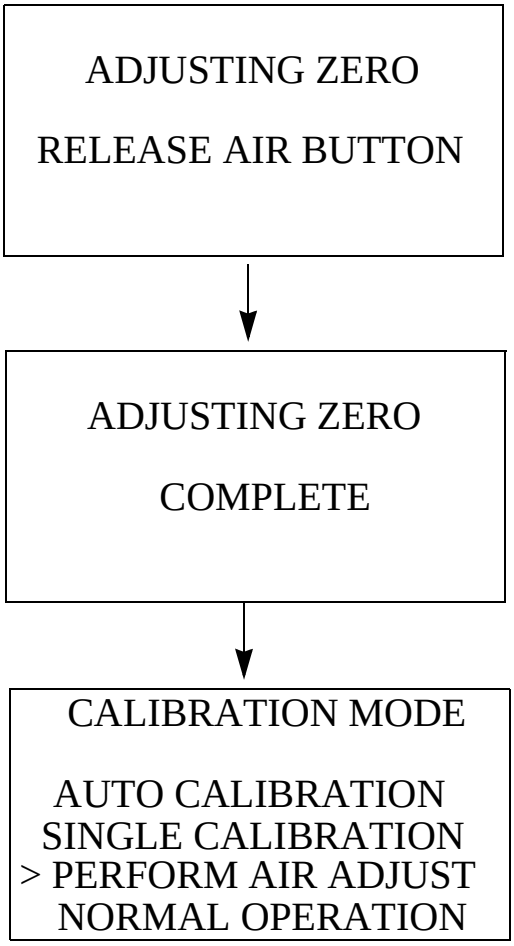
1. While in the Calibration Mode Screen, move the cursor to the **PERFORM AIR ADJUST** menu item by using the RANGE ▼ SHIFT button.



2. Press and release the POWER ENTER RESET button. The following screen appears.



3. Press and release the AIR ▲ YES button to continue.
   If you do not want to continue, press the DISPLAY ADJUST NO button and the unit will return to the Calibration Mode Screen.
4. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.



Performing a Span Adjustment in Auto Calibration

1. Slide the tubing clamp onto the tubing and connect the tubing to the sample bag's inlet fitting. Leave the clamp unclamped for now.
2. Install the probe on the EAGLE 2 inlet fitting. Make sure the probe is complete with internal O-ring and membrane and that the two halves of the probe are tightened firmly together to avoid leaks that can affect the calibration. See Figure 20, "Replacing the Hydrophobic Filter Disk & O-ring" on page 73 for an illustration of the internal parts of the probe.

3. Move the cursor next to the **AUTO CALIBRATION** menu item by using the AIR ▲ YES button.

```
CALIBRATION MODE

> AUTO CALIBRATION
  SINGLE CALIBRATION
  PERFORM AIR ADJUST
  NORMAL OPERATION
```

4. Press and release the POWER ENTER RESET button to display the Calibration Gas Values Screen.

```
CAL GAS VALUES
CH4     50  %LEL
OXY   12.0  vol%
H2S   25.0  ppm
CO      50  ppm
ENTER TO BEGIN CAL
```

   The gas concentrations displayed in the Calibration Gas Values Screen must match the gas concentrations listed on the 4-gas calibration cylinder.
   If *all* concentrations match, go to Step 15.
   If *one or more* concentrations *do not* match, continue with Step 5.
   If you do not want to continue with the calibration, press and release the DISPLAY ADJUST NO button to return to the Calibration Mode Screen.

NOTE: The RKI 4-gas cylinder typically contains 12% O_2 by volume. When using the auto calibration method, be sure to set the "OXY" auto calibration gas value to agree with the concentration listed on the cylinder's label, not zero.

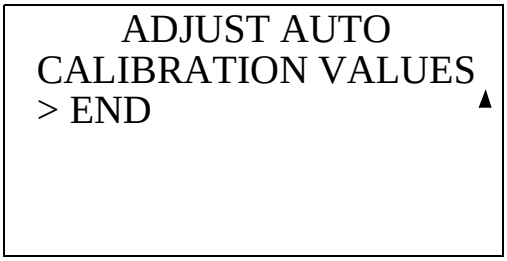
5. To adjust the values on the screen, hold down the RANGE ▼SHIFT button, then press the DISPLAY ADJUST NO button and release both. The following screen appears with the cursor next to **CH4**.

```
ADJUST AUTO
CALIBRATION VALUES
> CH4     50   %LEL
  OXY   12.0   vol%
  H2S   25.0   ppm
  CO      50   ppm      ▼
```

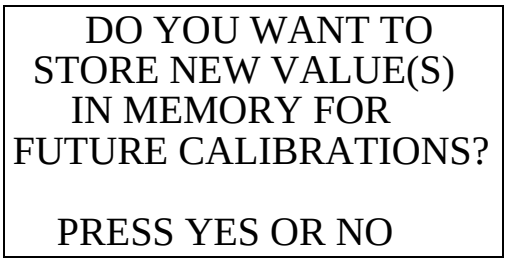
6. Place the cursor next to the channel whose gas value you want to change using the AIR ▲ YES and RANGE ▼SHIFT buttons.
7. Press and release the POWER ENTER RESET button to select the

channel. The calibration gas value begins to flash.

8. Use the AIR ▲ YES and RANGE ▼ SHIFT buttons to adjust the calibration gas setting to the desired value.
9. Press and release the POWER ENTER RESET button to save the change. The calibration gas value stops flashing.
10. Repeat Step 6 through Step 9 for any other channels that need to be changed.
11. When you are done adjusting the calibration gas values, move the cursor down past the bottom of the screen next to **END**.



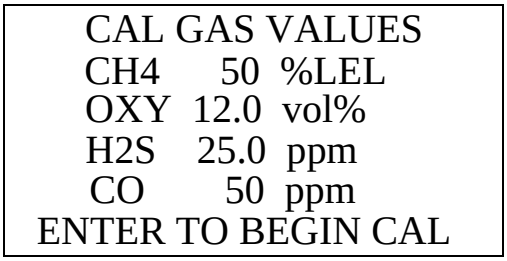
12. Press and release the POWER ENTER RESET button. The following screen appears.



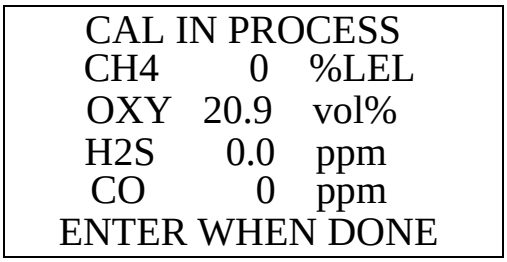
13. If you select YES by pressing and releasing the AIR ▲ YES button, the changes that you made will be saved in the EAGLE 2's memory as the new auto calibration gas values.

    If you select NO by pressing and releasing the DISPLAY ADJUST NO button, the changes you made will be used for any calibrations performed during the current operating session only. The EAGLE 2 will delete the changes when the unit is turned off and will load the previous set of auto calibration values when it is turned on again.

14. When you make your selection and press the desired button, the unit returns to the Calibration Gas Values Screen.



15. Press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen. **CAL IN PROCESS** is flashing.

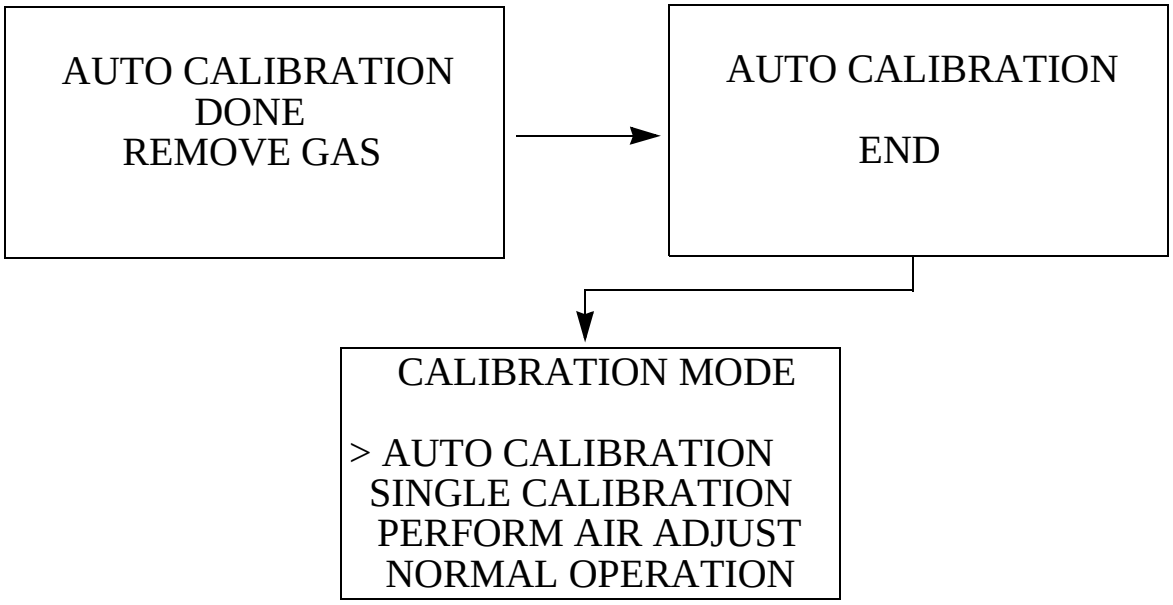


If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the Calibration Gas Values Screen.

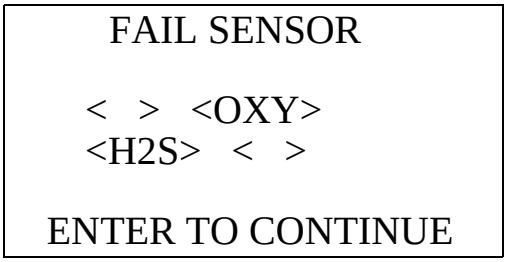
If you do want to continue with the calibration, proceed to the next step.

16. Connect the gas bag tubing to the regulator's or dispensing valve's hose barb fitting.
17. Fill the gas collection bag by screwing the fixed flow regulator or dispensing valve onto the calibration cylinder and turning the knob counterclockwise.
18. Allow the gas to dispense until the gas collection bag is a little over half full.
19. Turn the knob clockwise to stop the gas flow, clamp down the hose clamp and remove the regulator or dispensing valve from the cylinder.
20. Disconnect the tubing from the regulator or dispensing valve.
21. Open the hose clamp on the gas bag tubing.
22. Connect the tubing from the gas bag to the rigid tube on the probe. Allow the gas to flow for one minute.
23. Press and release the POWER ENTER RESET button to set the span adjustment to the programmed values.

24. If all channels passed calibration the following screen sequence occurs.



If any of the sensors cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and lists the sensor(s) that failed to calibrate. In the example below, the oxygen and H_2S channels failed calibration. The other sensors calibrated normally.



The buzzer and LED arrays activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and return to the Calibration Mode Screen. Attempt to calibrate again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

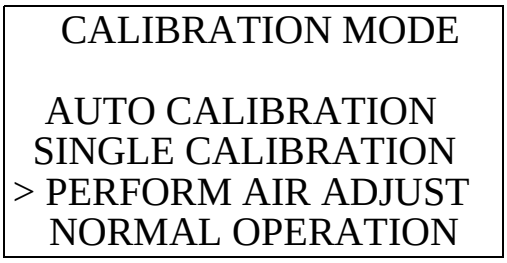
25. Disconnect the tubing from the probe.
26. Use the RANGE ▼ SHIFT button to place the cursor next to the **NORMAL OPERATION** menu option, then press and release the POWER ENTER RESET button to return to Measuring Mode.

Calibrating Using the Single Calibration Method

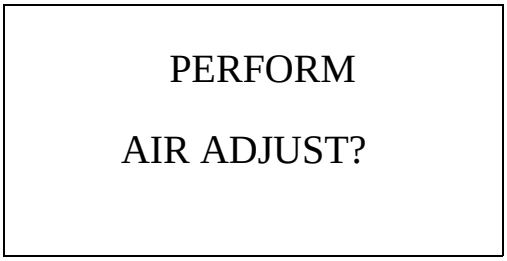
Single Calibration allows you to calibrate one channel at a time. This is useful if you only want to calibrate one or two channels.

Setting the Fresh Air Reading

1. While in the Calibration Mode Screen, move the cursor to the **PERFORM AIR ADJUST** menu item by using the RANGE ▼ SHIFT button.

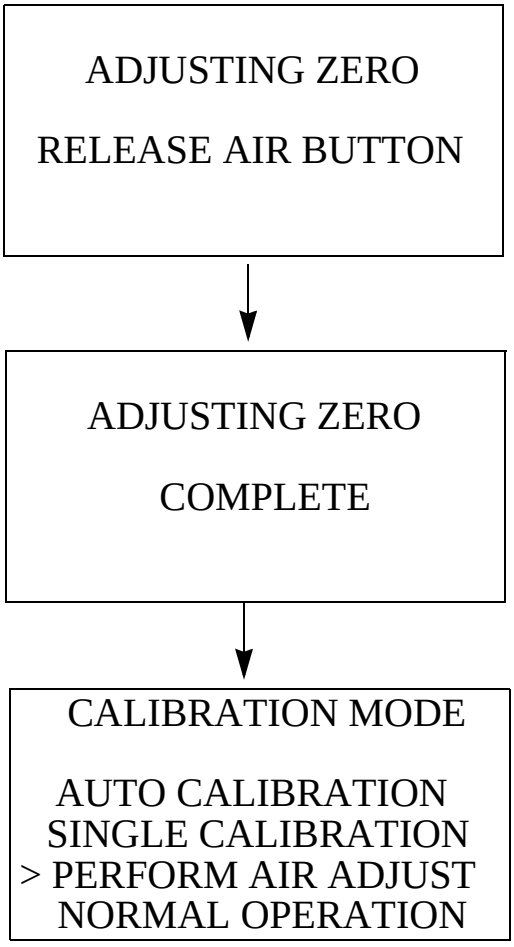


2. Press and release the POWER ENTER RESET button. The following screen appears.



3. Press and release the AIR ▲ YES button to continue.
   If you do not want to continue, press the DISPLAY ADJUST NO button and the unit will return to the Calibration Mode Screen.

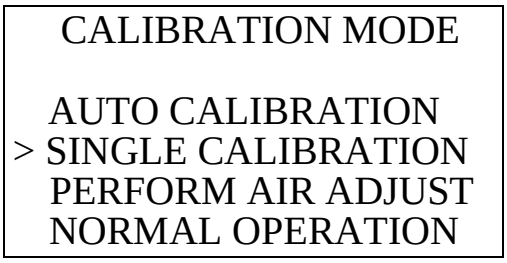
4. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.



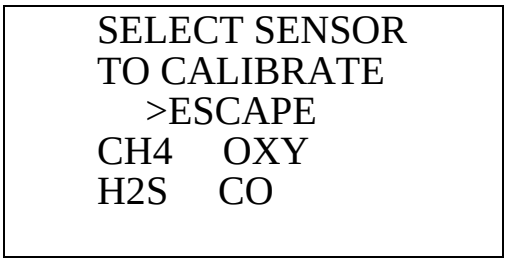
Performing a Span Adjustment in Single Calibration

1. Slide the tubing clamp onto the tubing and connect the tubing to the sample bag's inlet. Leave the clamp unclamped for now.
2. Connect the other end of the tubing to the regulator's or dispensing valve's hose barb fitting.
3. Install the probe on the EAGLE 2 inlet fitting. Make sure the probe is complete with internal O-ring and membrane and that the two halves of the probe are tightened firmly together to avoid leaks that can affect the calibration. See Figure 20, "Replacing the Hydrophobic Filter Disk & O-ring" on page 73 for an illustration of the internal parts of the probe.

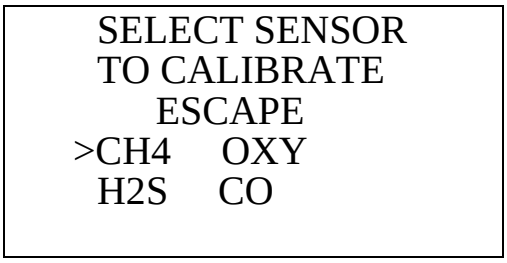
4. Move the cursor next to the **SINGLE CALIBRATION** menu item by using the AIR ▲ YES button.



5. Press and release the POWER ENTER RESET button. The Select Sensor Screen appears with the cursor flashing.



6. Move the cursor next to the sensor you want to calibrate with the AIR ▲ YES and RANGE ▼ SHIFT buttons. In the example below, the CH_4 sensor is selected for span adjustment.



If you do not want to proceed with the span adjustment, press and release the DISPLAY ADJUST NO button or place the cursor next to **ESCAPE** and press and release POWER ENTER RESET to return to the Calibration Mode Screen.

If you do want to continue with the calibration, proceed with the next step.

7. Press and release the POWER ENTER RESET button to proceed to the Single Calibration Gas Value Screen for the selected channel. The calibration gas value is flashing.

```
SINGLE CALIBRATION

   CH4    50 %LEL
UP/DOWN TO ADJUST
CALIBRATION VALUE
  ENTER WHEN DONE
```

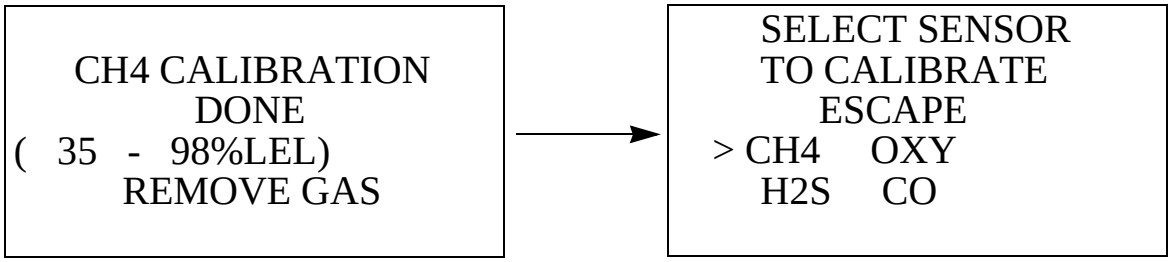
8. If necessary, adjust the calibration gas value to match the cylinder concentration using the AIR ▲ YES and RANGE ▼ SHIFT buttons. For this example, the calibration gas value is entered as 50 %LEL.
9. Press and release the POWER ENTER RESET button to proceed to the Single Calibration Apply Gas Screen. **CAL IN PROCESS** is flashing.

```
SINGLE CALIBRATION
     APPLY GAS
   CH4     0 %LEL

   CAL IN PROCESS
  ENTER WHEN DONE
```

10. Fill the gas collection bag by screwing the fixed flow regulator or dispensing valve onto the calibration cylinder and turning the knob counterclockwise.
11. Allow the gas to dispense until the gas collection bag is a little over half full.
12. Turn the knob clockwise to stop the gas flow, clamp down the hose clamp and remove the regulator or dispensing valve from the cylinder.
13. Disconnect the tubing from the regulator or dispensing valve.
14. Open the hose clamp on the gas bag tubing.
15. Connect the tubing from the gas bag to the rigid tube on the probe. Allow the gas to flow for one minute.
16. Press and release the POWER ENTER RESET button to make the span adjustment.
17. When the span adjustment is made, the EAGLE 2 calculates the range of adjustment, minimum and maximum, it could have made based on its response level to the applied gas. This calculated range is independent of the calibration gas value that was entered in Step 8 and Step 9 above. The

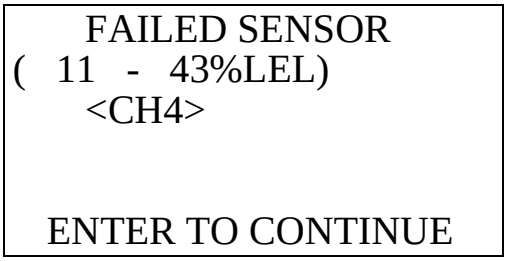
adjustment range is included on the result screen to indicate the condition of the sensor. If the calibration gas value is in the adjustment range, the span adjustment will pass. If the calibration gas value is out of the adjustment range, the span adjustment will fail.

18. If the span adjustment is successful, the following screens display.



In the example above, the EAGLE 2 could have adjusted the reading as low as 35 %LEL and as high as 98 %LEL.

If the span adjustment is not successful, a screen displays that indicates a calibration failure.



In the example above, the EAGLE 2 could have adjusted the reading as low as 11 %LEL and as high as 43 %LEL. Since the calibration gas value entered was 50 %LEL, the unit failed the span adjustment. The buzzer and alarm LED arrays activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and return to the Select Sensor Screen. Attempt to calibrate again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

NOTE: The adjustment range will only appear in the calibration results screen if the Span Factor item in Setup Mode is set to ON. If the Span Factor is set to OFF, the adjustment range will not appear.

19. Disconnect the tubing from the EAGLE 2’s probe.
20. Repeat Step 6 through Step 19 for any other channels you want to calibrate. Make sure you use an appropriate calibration cylinder for each channel.

CAUTION: *When calibrating the oxygen channel, verify the concentration of oxygen listed on the cylinder's label. For oxygen-free samples (100% nitrogen for example), set the oxygen zero setting to 0.0%.*

21. After the last channel is calibrated, disconnect the calibration tubing from the probe.
22. With the Select Sensor Screen displayed, place the cursor next to **ESCAPE** using the AIR ▲ YES button.

```
SELECT SENSOR
TO CALIBRATE
   >ESCAPE
CH4    OXY
H2S    CO
```

23. Press and release the POWER ENTER RESET button to return to the Calibration Mode Screen.
24. Use the RANGE ▼ SHIFT button to place the cursor next to the **NORMAL OPERATION** menu item, then press and release the POWER ENTER RESET button to return to Measuring Mode.

Parts List

Table 12: Sample Bag Calibration Kit Spare Parts

Part Number	Description
06-1248RK-03	Calibration kit tubing,3 foot length
81-0090RK-01	Calibration cylinder, 3-gas mix, LEL/Oxygen/CO, 34 liter steel
81-0154RK-04	Calibration cylinder, 4-gas mix, LEL/Oxygen/CO/H_2S, 34 liter aluminum
81-1001RK	Dispensing valve, for 17/34 liter steel cylinders
81-1051RK-60	Regulator with gauge and knob, 34 liter aluminum/58 liter/103 liter cylinders, 6 LPM
81-1126RK	Gas bag with clamp and hose barb, 9" x 9", 2 liter
81-5302RK-LV	Calibration kit, for LEL/Oxy/CO unit, w/gas bag, 34 Liter
81-5401RK-LV	Calibration kit, for LEL/Oxy/H_2S/CO unit, w/gas bag, 34 Liter

Appendix B: Setup Mode

Overview

This appendix describes the EAGLE 2 in Setup Mode. In Setup Mode, you can:

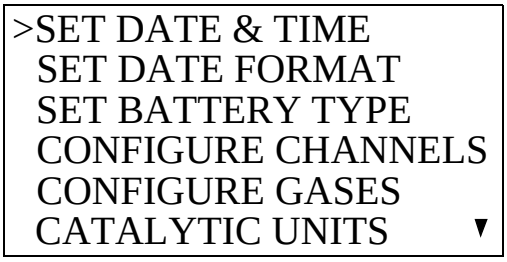
- set the date and time
- set the date format
- set the battery type
- configure the channels
- configure the gas for a catalytic or PID channel
- set the detection units for the catalytic channel
- turn the catalytic sensor relative response feature on or off
- set the alarm points
- change the alarm latching setting
- turn the alarm silence feature on or off
- turn the user/station ID function on or off
- set the auto calibration values
- set the backlight delay time
- turn the automatic fresh air adjust feature on or off
- set the data logging interval time
- turn the data logger overwrite feature on or off
- turn the data log memory clear feature on or off
- adjust the display contrast
- turn the calibration reminder feature on or off
- set the calibration past due action
- set the calibration interval
- select the leak check/bar hole mode operation setting
- set the bar hole measurement time
- turn the zero follower on or off for each channel
- set the zero suppression level for each channel (except oxygen)

- turn the confirmation alert feature on or off
- turn the password feature on or off and set the password
- reset the instrument parameters to their default settings
- turn the lunch break function on or off
- turn the span factor on or off
- select the language
- return to normal operation

The EAGLE 2 is factory-set to suit most applications. Update settings in Setup Mode only if required for your specific application. The description of each item below indicates the factory setting for each item.

Tips for Using Setup Mode

- When in the main menu, the cursor (>) flashes in front of a menu item indicating that the item is selected.
- Use the RANGE ▼ SHIFT button to move the cursor down through the main menu and submenu items, and to lower values or change the setting in a specific option.
- Use the AIR ▲ YES button to move the cursor up through the main menu and submenu items, and to raise values or change the setting in a specific option.
- A down arrow in the lower right corner or an up arrow in the upper right corner of the LCD indicates that additional menu items can be viewed by pressing and releasing the RANGE ▼ SHIFT button in the case of the down arrow or the AIR ▲ YES button in the case of the up arrow. The example below illustrates a down arrow in the lower right corner.



- Use the POWER ENTER RESET button to enter a selected menu item with the cursor next to it and to enter and save settings during programming.
- An adjustable parameter that is flashing can be adjusted with the AIR ▲

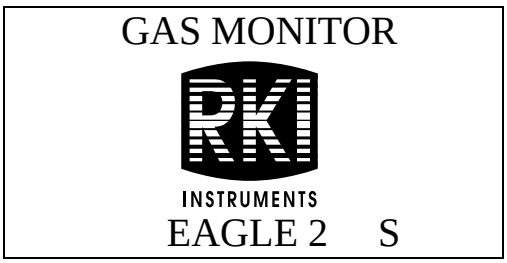
YES and RANGE ▼ SHIFT buttons.

- Press the DISPLAY ADJUST NO button while in a screen where you are entering or updating parameters to exit the screen without saving any changes.

Using Setup Mode

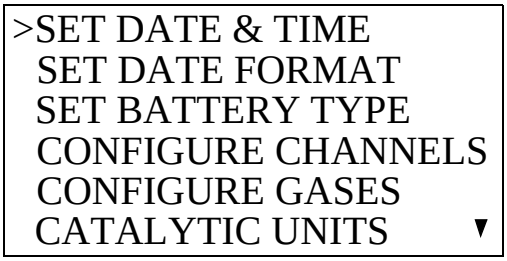
WARNING: The EAGLE 2 is not in operation as a gas detector while in Setup Mode.

1. Take the EAGLE 2 to a non-hazardous location and turn it off if it is on.
2. Press and hold the AIR ▲ YES and RANGE ▼ SHIFT buttons, then press and hold the POWER ENTER RESET button. When you hear a beep, release the buttons.
3. The LCD will show the following screen for a few seconds with the “S” in the lower right corner indicating the unit is entering Setup Mode.



4. The “S” will then disappear and the following screen will appear for a few seconds.

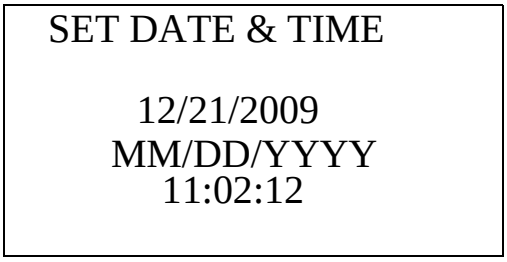
5. If the unit prompts you for the password, enter it by using the AIR ▲ YES and RANGE ▼ SHIFT buttons to select each password number and then pressing and releasing the POWER ENTER RESET button to enter it and move on to the next number until all of the numbers are entered. The main menu displays. It displays six menu items at a time.



6. Use the AIR ▲ YES or RANGE ▼ SHIFT button to move the cursor up and down the menu items and to view additional menu items. A down arrow in the lower right corner of the LCD or an up arrow in the upper right corner of the LCD indicates that there are additional menu items accessible by moving the cursor down past the last menu item on the LCD or up past the first menu item on the LCD.

Setting the Date and Time

1. From the main menu, place the cursor next to **SET DATE & TIME**.
2. Press and release POWER ENTER RESET. The date and time will be displayed with the last two digits of the year flashing.



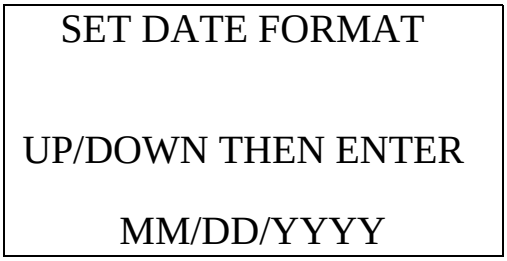
3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired year.
4. Press and release POWER ENTER RESET to save the setting. The month setting flashes.
5. Repeat Step 3 and Step 4 to enter the month, day, hours, minutes, and seconds settings. The main menu displays after you enter the seconds setting.

Setting the Date Format

The date can be displayed in two ways, month / day / year (factory setting) or day / month / year.

1. From the main menu, place the cursor next to **SET DATE FORMAT**.

2. Press and release POWER ENTER RESET. The Set Date Format screen appears with the current setting flashing.

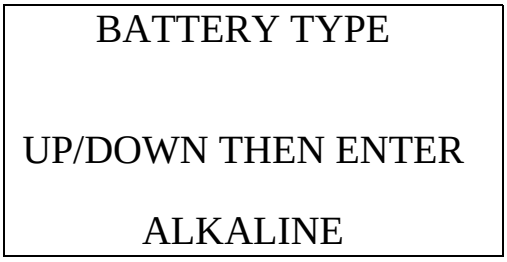


3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Setting the Battery Type

This menu item allows you to select between alkaline and Ni-MH batteries. Since the discharge characteristics of alkaline and Ni-MH batteries are different, the EAGLE 2 uses this setting to ensure that the low battery *warning* is in effect long enough before a dead battery *alarm* to allow the user to change the batteries without a dead battery alarm occurring. This setting has no effect on battery charging.

1. From the main menu, place the cursor next to **SET BATTERY TYPE**.
2. Press and release POWER ENTER RESET. The Battery Type screen appears with the current setting flashing.



3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Configuring the Channels

This menu item allows you to set the channel type for each of the six channels or to turn one or more channels off. Although the standard EAGLE 2 is factory configured for four channels, combustible gas (catalytic sensor), oxygen, H_2S, and CO, with channels 5 and 6 turned off, the EAGLE 2 can be factory and field configured for a variety of active channels and detector types. It is not normally necessary to

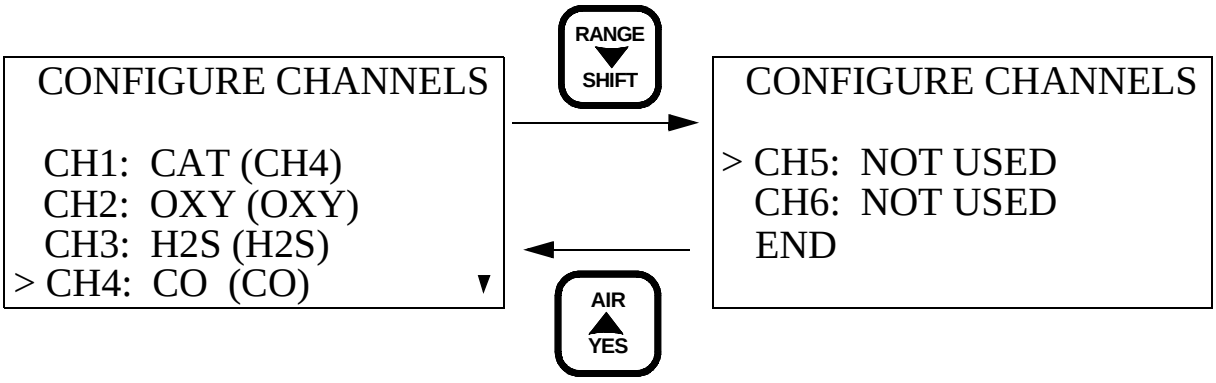
change the factory channel configuration.

CAUTION: *Before changing the channel configuration, confirm that the correct sensors and electronic hardware are installed in the EAGLE 2 and that its construction and flow system are appropriate for the installed sensors. Operation of the EAGLE 2 with a flow system or construction not compatible with the installed sensors will result in inaccurate readings. Consult RKI Instruments, Inc. if you cannot confirm either of these items.*

1. From the main menu, place the cursor next to **CONFIGURE CHANNELS**.
2. Press and release POWER ENTER RESET. The Configure Channels screen appears with the cursor flashing next to **CH1**.

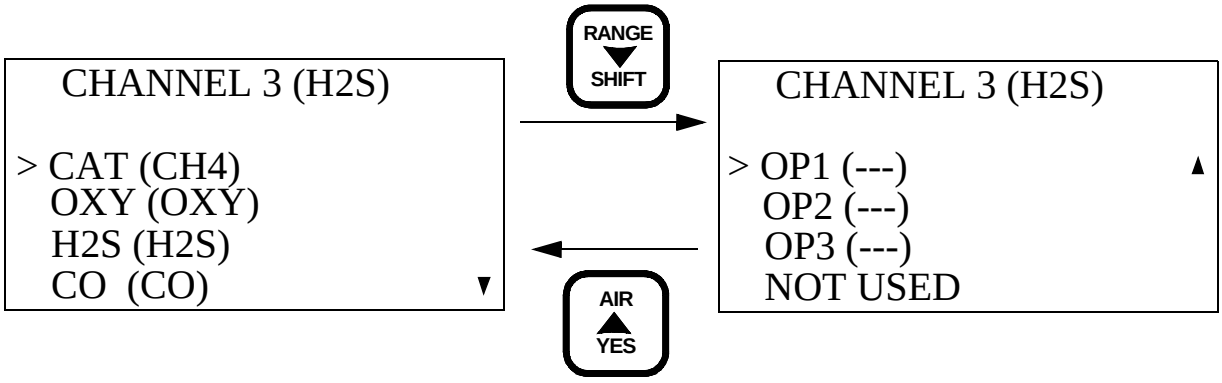
```
 CONFIGURE CHANNELS

> CH1:  CAT (CH4)
  CH2:  OXY (OXY)
  CH3: H2S (H2S)
  CH4:  CO  (CO)          ▼
```

The standard 4-gas configuration is shown below.

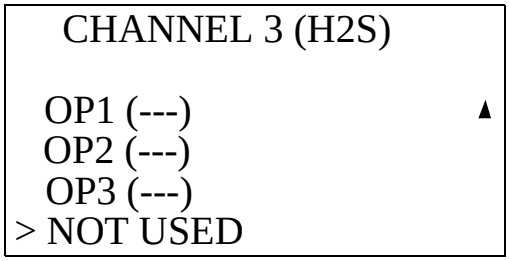


3. Use AIR ▲ YES or RANGE ▼ SHIFT to move the cursor next to the channel you want to configure.

4. Press and release POWER ENTER RESET. The available configuration options are shown. In the example below, channel 3 has been selected for configuration.

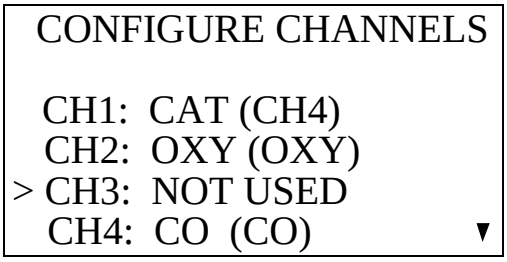


5. Use AIR ▲ YES and RANGE ▼ SHIFT to move the cursor next to the desired configuration for the selected channel. In the example below, the cursor has been moved next to the **NOT USED** selection.



The OP1, OP2, and OP3 options are not defined for a standard 4-gas EAGLE 2. These options are only defined when hardware specific to optional sensors is factory installed in the EAGLE 2. The "---" in the gas name field indicates that hardware necessary to support an optional sensor is not installed. If your EAGLE 2 supports one or more of these optional sensors, the target gas will appear instead of "---". See "Appendix C: Sub PCBs" on page 129 for a description of this optional hardware and how it affects CHANNEL CONFIGURATION.

6. Press and release POWER ENTER RESET to select the channel configuration. In the example below, channel 3 has been turned off by selecting **NOT USED**.



7. Repeat Step 5 and Step 6 for any other channels you want to configure.

8. Use RANGE ▼SHIFT to move the cursor next to the **END** menu item.

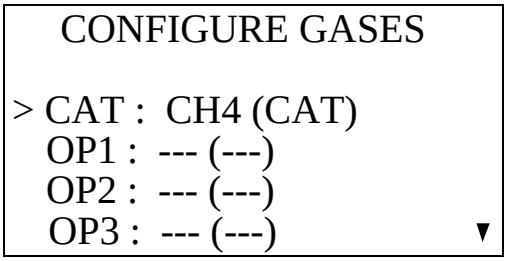
NOTE: If you want to exit to the main menu without saving any channel configuration changes, press and release DISPLAY ADJUST NO.

9. Press and release POWER ENTER RESET to save the changes and return to the main menu.

Configuring the Combustible Gas

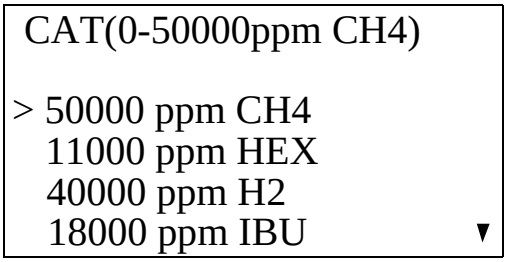
This menu item allows you to configure the gas for a catalytic, TC (thermal conductivity), or PID (photo ionization detector) sensor. Only a catalytic sensor is used in a standard EAGLE 2, so only a catalytic sensor can be configured in a standard EAGLE 2. PID or TC sensors can only be configured if additional hardware not in a standard EAGLE 2 is factory installed.

1. From the main menu, place the cursor next to **CONFIGURE GASES**.
2. Press and release POWER ENTER RESET. The Configure Gases Screen appears with the cursor flashing next to CAT.

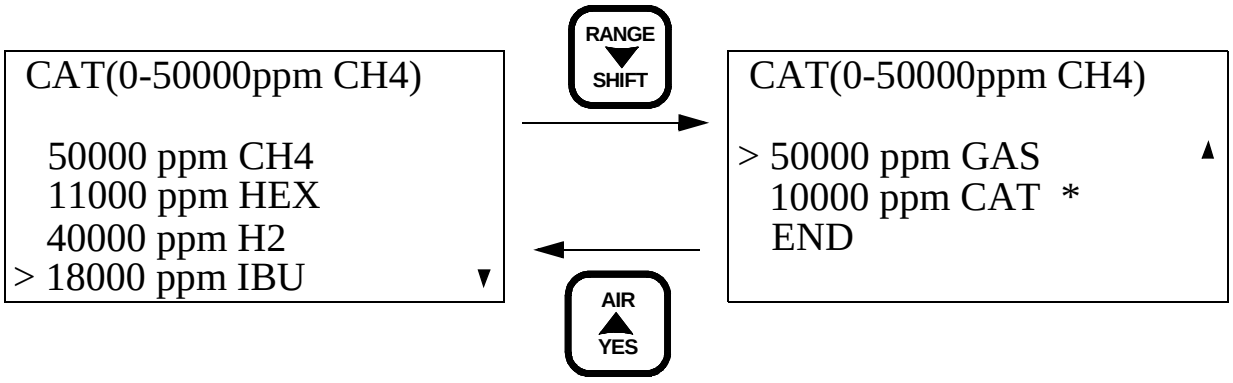


The OP1, OP2, and OP3 options are not defined in a standard 4-gas EAGLE 2. These options are only defined when hardware specific to optional sensors is factory installed in the EAGLE 2. See “Appendix C: Sub PCBs” on page 129 for a description of this optional hardware and how it affects CONFIGURE GASES.

3. To change the catalytic sensor gas configuration, press and release POWER ENTER RESET.
4. A screen appears with gas configuration choices for the catalytic channel.



For each gas, the LEL (lower explosive limit) and gas name is displayed. The LEL is shown in terms of ppm. The available choices are on two screens.



All of the gases except for the one with the asterisk (*) next to it are pre-defined. The gas with the asterisk next to it is user defined. The user defined gas can be used if the desired gas is not one of the pre-defined gases. Below is a brief description of each choice.

- 50000 ppm CH4
  This selection is for methane (CH_4) and is the standard factory setting. The LEL for methane is 5 %volume, or 50,000 ppm. If the gas is configured for this choice, the methane elimination feature is inactive and the Methane Elimination Mode Screen will not appear in Display Mode. See “Methane Elimination Mode Screen” on page 42 for a description of the Methane Elimination Mode Screen. See “Appendix J: Methane Elimination Mode” for a description of Methane Elimination Mode.

- 11000 ppm HEX
  This selection is for hexane. The LEL for hexane is 1.1%, or 11,000 ppm. If the gas is configured for this choice, the methane elimination feature is active and the Methane Elimination Mode Screen is accessible in Display Mode. See “Methane Elimination Mode Screen” on page 42 for a description of the Methane Elimination Mode Screen. See “Appendix J: Methane Elimination Mode” for a description of Methane Elimination Mode.

- 40000 ppm H2
  This selection is for hydrogen (H_2). The LEL for hydrogen is 4%, or 40,000 ppm. If the gas is configured for this choice, the methane elimination feature is inactive, the Methane Elimination Mode Screen will not appear in Display Mode, and the catalytic sensor voltage is set to 1.1 volts. The standard catalytic sensor voltage is 2.4 volts.

Because the detector voltage is set to 1.1 volts, the catalytic sensor will not respond significantly to methane and many other combustible gases, but will respond to hydrogen.

WARNING: ***Do not configure the catalytic sensor gas to hydrogen if you are monitoring for general hydrocarbons. Only use this selection if you are monitoring exclusively for hydrogen or if you do not want to see a significant response to other combustible gases.***

- 18000 ppm IBU
  This selection is for isobutane. The LEL for isobutane is 1.8%, or 18,000 ppm. If the gas is configured for this choice, the methane elimination feature is inactive and the Methane Elimination Mode Screen will not appear in Display Mode. See "Methane Elimination Mode Screen" on page 42 for a description of the Methane Elimination Mode Screen. See "Appendix J: Methane Elimination Mode" for a description of Methane Elimination Mode.
- 50000 ppm GAS
  This selection is for a generic combustible gas with the LEL set to 50000 ppm. If the gas is configured for this choice, the methane elimination feature will be active, but the Methane Elimination Mode Screen will not appear in Display Mode, so methane elimination cannot be turned off. In addition, the relative response feature is inactive even if it is set to ON in the Setup Mode Relative Responses menu item.

CAUTION: *The* **50000 ppm GAS** *gas configuration is normally set at the factory for very specific applications. Consult RKI Instruments, Inc. before configuring the gas for* **50000 ppm GAS**.

- 10000 ppm CAT *
  This selection is a user defined selection. The factory setting is 10000 ppm CAT *, with the asterisk (*) indicating that it is user defined. If this selection has been updated in the field, it will appear differently, but the asterisk will always remain next to the menu item to indicate it is user defined. If you choose the user defined selection, the unit will prompt you to enter four parameters: a three character gas name, the LEL value in terms of ppm, the response factor relative to methane, and the detector voltage. When you configure the gas as the user defined choice, the methane elimination feature is active and the Methane Elimination Mode Screen is accessible in Display Mode. See "Methane Elimination Mode Screen" on page 42 for a

description of the Methane Elimination Mode Screen. See “Appendix J: Methane Elimination Mode” for a description of Methane Elimination Mode.

5. Use AIR ▲ YES and RANGE ▼ SHIFT to move the cursor next to the desired gas for the catalytic channel.
6. If you placed the cursor next to one of the pre-defined gases, press and release POWER ENTER RESET to select the gas and proceed to Step 15.

   If you placed the cursor next to the user defined gas with the asterisk (*), press POWER ENTER RESET and proceed with Step 7.
7. The user defined gas setup screen appears with the first character of the gas name flashing. The current gas name and range are shown on the top line of the screen.

```
CAT(0-10000ppm CH4)
  CHANGE TO NAME
  CAT
  10000 - 150000
  10000 ppm RATIO
    1.00 FACTOR
```

8. Enter the gas name. Use AIR ▲ YES and RANGE ▼ SHIFT to display the desired character, then press POWER ENTER RESET to enter the displayed character and move to the next character. Repeat until all three characters are entered. When the last character is entered, the ppm ratio value will be flashing.
9. Use AIR ▲ YES and RANGE ▼ SHIFT to display the desired ppm value. This value is called the ppm ratio and must be the ppm equivalent of the LEL for the gas being defined. For example, if you are defining propane, the LEL for propane is 21,000 ppm, so you must enter 21000 ppm (2.1% volume).

NOTE: If you define a gas whose LEL is above 50,000 ppm, the %LEL reading in Measuring Mode will reflect the defined ppm ratio, but the ppm reading in Measuring Mode will not indicate above 50,000 ppm. For example, if you set the ratio to be 150,000 ppm and set the catalytic combustible channel to display the reading in ppm, the gas reading will not indicate higher than 50,000 ppm, the equivalent of 33 %LEL and 5% volume for this ratio, but will continue to indicate %LEL readings up to 100 %LEL and %volume readings up to 15 %volume, the equivalent of 150,000 ppm, if the display units are changed to %LEL or %volume. In addition, all adjustable ppm parameters cannot be set higher than 50,000 ppm.

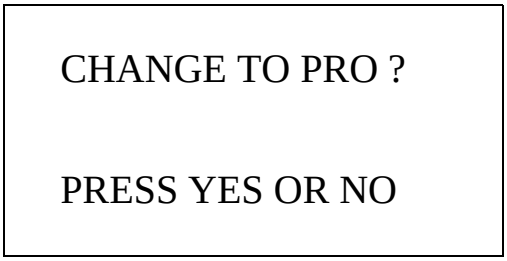
10. Press and release POWER ENTER RESET to enter the ppm ratio. The FACTOR for the gas begins to flash. The FACTOR for the gas is the response factor for the user defined gas relative to methane. The response factor must be obtained by testing the user defined gas and comparing its response to methane. This parameter is used by the relative response feature. See “Catalytic Sensor Relative Response Screen” on page 43 for a description of the relative response feature and how to use it. See “Combustible Gas Detection” on page 30 for a list of response factors for several common hydrocarbon gases that have already been tested.
11. Use AIR ▲ YES and RANGE ▼ SHIFT to increase or decrease the response factor to the desired number.
12. Press and release POWER ENTER RESET to enter the response factor. The sensor voltage setting screen appears with the sensor voltage flashing. The current gas and range is shown at the top of the screen and the current sensor voltage is shown at the bottom of the screen.

CAT(0-50000ppm CH4)
SETTING EV UP/DOWN THEN ENTER
2.40

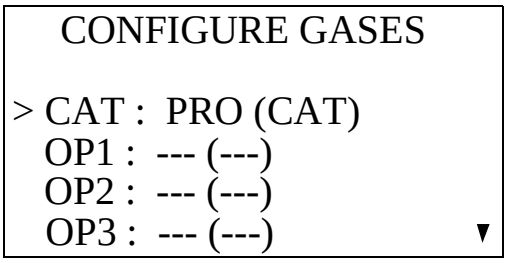
The sensor voltage setting defines whether the catalytic sensor voltage is set for full response, 2.40 volts, or methane elimination, 1.30 volts. If the sensor voltage is set to 2.40 volts, the unit will default to Full Response Mode when turned on, but the methane elimination feature can be turned on in the Methane Elimination Mode Screen in Display Mode. If the sensor voltage is set to 1.3 volts, the unit will default to Methane Elimination Mode when turned on, but the methane elimination feature can be turned off in the Methane Elimination Mode Screen in Display Mode.

13. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired catalytic sensor voltage, 1.30 volts or 2.40 volts.

14. Press and release POWER ENTER RESET. The confirmation screen appears. In the example below, the user defined gas has been selected and defined as propane with the gas name set to PRO.



15. If you want to accept the gas configuration change, press and release AIR ▲ YES. The unit will return to the Configure Gases screen.



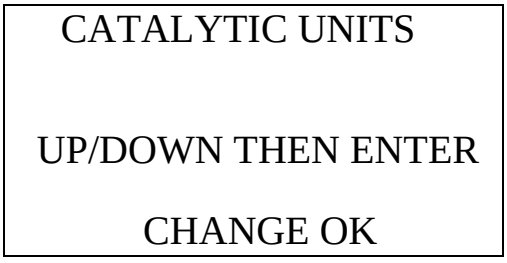
If you do not want to accept the gas configuration change, press and release DISPLAY ADJUST NO to return to the screen with the gas choices shown in Step 4 on page 104. You can either scroll down to **END** and press POWER ENTER RESET to return to the Configure Gases screen or continue from Step 4 on page 104 to select a new gas.

16. Use RANGE ▼SHIFT to place the cursor next to **END** and press POWER ENTER RESET to return to the main menu.

Setting the Catalytic Detection Units

This menu item allows you to display the combustible gas units on the catalytic sensor channel as ppm, %LEL, %vol, or selectable between the three units (the **CHANGE OK** option). The factory setting is **CHANGE OK**.

1. From the main menu, place the cursor next to **CATALYTIC UNITS**.
2. Press and release POWER ENTER RESET. The Catalytic Units screen appears with the current setting flashing at the bottom of the screen.



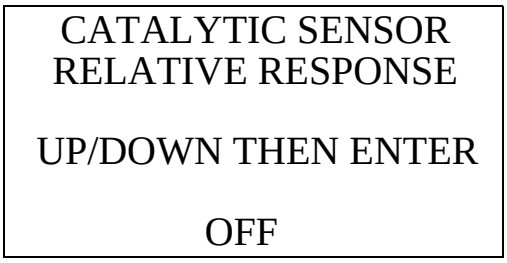
3. Use AIR ▲ YES or RANGE ▼ SHIFT to scroll through the choices, **CHANGE OK**, **vol% ONLY**, **%LEL ONLY**, and **ppm ONLY**.
4. When the desired setting is on the screen, press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Catalytic Sensor Relative Response Setting

This menu item allows you to turn the catalytic sensor relative response feature on and off. The catalytic sensor relative response feature enables you to change the catalytic sensor's response to gas on the fly so that the catalytic channel is roughly calibrated to an alternate gas. For example, if the catalytic channel is setup for and calibrated to methane, you can select hexane from a gas list accessible from the Catalytic Sensor Relative Response Screen in Display Mode so that the catalytic channel responds to gas as if it were calibrated to hexane. See "Catalytic Sensor Relative Response Screen" on page 43 for instructions to use the relative response feature.

The factory setting for **CATALYTIC SENSOR RELATIVE RESPONSE** is **OFF**.

1. From the main menu, place the cursor next to **RELATIVE RESPONSE**. Press and release POWER ENTER RESET. The Catalytic Sensor Relative Response screen appears with the current setting flashing.



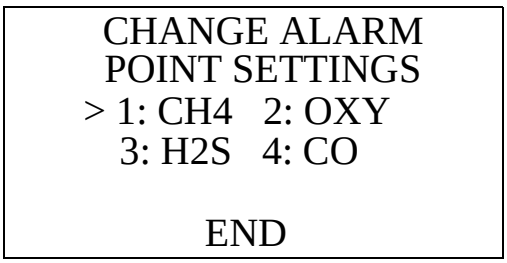
2. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting, **ON** or **OFF**.
3. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Alarm Point Settings

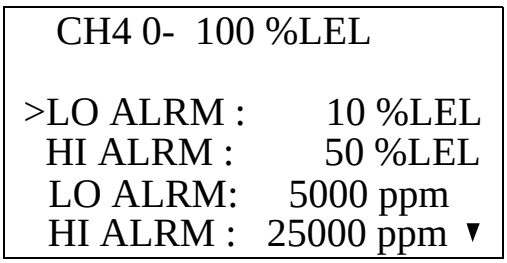
This menu item allows you to update one or more alarm points (the reading at which the EAGLE 2 recognizes the alarm condition).

1. From the main menu, place the cursor next to **ALARM POINTS**.

2. Press and release POWER ENTER RESET. The Change Alarm Point Settings Screen appears and all detection channels are displayed.



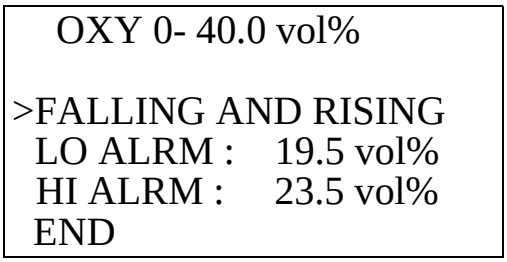
3. Move the cursor next to the channel of the alarm point you want to update. Press and release POWER ENTER RESET. The channel's alarm points are displayed (in this example for the catalytic combustible sensor channel).



4. Move the cursor next to the alarm point or alarm operation (oxygen only) that you want to update.

   If you selected the oxygen channel, you can set the alarm rising/falling operation in addition to the alarm points.

NOTE: If Inert Mode is active, you can change the oxygen alarm points for both Normal Mode and Inert Mode. For more information about changing Inert Mode alarm settings, see "Appendix N: Using the EAGLE 2 in Inert Mode" on page 269.



5. Press and release POWER ENTER RESET. The alarm point or alarm operation (oxygen only) will begin to flash.
6. Use AIR ▲ YES and RANGE ▼ SHIFT to adjust the alarm point or alarm operation (oxygen only) to the desired setting. Keep the following in mind:

- The low alarm cannot be set higher than the high alarm and the high alarm cannot be set lower than the low alarm.
- Any alarm setting can be turned off by adjusting it to its lowest setting. The setting will be displayed as **OFF.**
- In addition to setting the oxygen alarm points, you can also select one of the following operation modes: low alarm decreasing and high alarm increasing (**FALLING AND RISING**); low and high alarm decreasing (**BOTH FALLING**); low and high alarm increasing (**BOTH RISING**). The factory setting is **FALLING AND RISING**.

7. If you want to continue with the change, press and release POWER ENTER RESET to accept the setting.

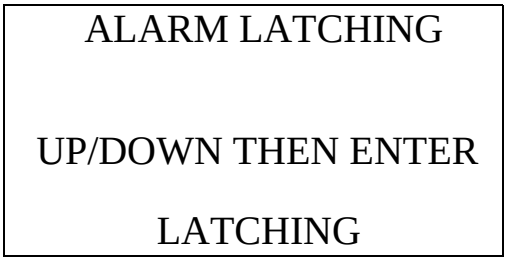
   If you want to exit this screen without saving any change to the alarms, press and release DISPLAY ADJUST NO until you return to the Change Alarm Point Settings Screen.
8. Repeat Step 4- Step 7 for any additional changes you want to make.
9. When you are done making changes, use RANGE ▼SHIFT to move the cursor next to **END**.
10. Press and release POWER ENTER RESET to save the new settings and return to the Change Alarm Point Settings Screen.
11. Use RANGE ▼SHIFT to move the cursor next to **END.**
12. Press and release POWER ENTER RESET to return to the main menu.

Updating the Alarm Latching Setting

With **ALARM LATCHING** set to **LATCHING** (factory setting), the EAGLE 2 remains in alarm condition until the alarm condition passes *and* the POWER ENTER RESET button is pressed.

With **ALARM LATCHING** set to **SELF RESET**, the EAGLE 2 automatically resets an alarm when the alarm condition passes.

1. From the main menu, place the cursor next to **ALARM LATCHING**.
2. Press and release POWER ENTER RESET. The Alarm Latching Screen appears.



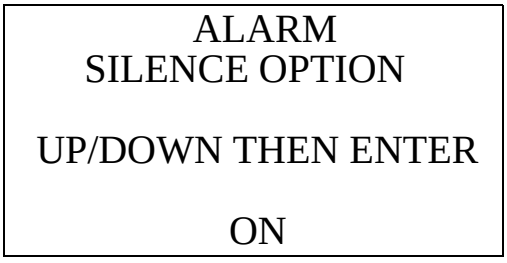
3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Alarm Silence Setting

With **ALARM SILENCE** set to **ON** (factory setting), pressing and releasing any button silences the buzzer when the EAGLE 2 is in alarm. The LEDs continue to flash and the display continues to show the alarm. When the gas concentration falls below the alarm level, pressing and releasing POWER ENTER RESET clears all alarm indications for that alarm. If an alarm condition occurs, you may still enter Display Mode by pressing the DISPLAY button. The buzzer will be silenced but the LEDs will continue to flash. If you return to Measuring Mode and there is still an alarm condition, the LEDs will continue to flash and the buzzer will remain off. Once the condition clears, press POWER ENTER RESET to clear the alarm indications.

With **ALARM SILENCE** set to **OFF**, you cannot silence the buzzer. If an alarm condition occurs, and you enter Display Mode, the buzzer will not be silenced and the LEDs will continue to flash. Upon return to Measuring Mode, if there is still an alarm condition, you must wait until it clears before you can press POWER ENTER RESET to clear the alarm indications.

1. From the main menu, place the cursor next to **ALARM SILENCE**.
2. Press and release POWER ENTER RESET. The Alarm Silence Option Screen appears.



3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

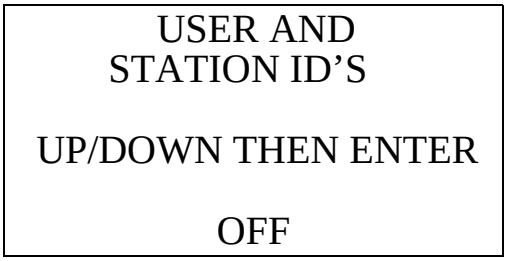
Turning the User/Station ID Function On or Off

With **USER/STATION ID** set to **ON**, the ID Screen displays during start up and the Select User ID Screen and Select Station ID Screen appear in Display Mode. The ID's can be selected in Display Mode.

With **USER/STATION ID** set to OFF (factory setting), the ID Screen

does not display during start up and the Select User ID Screen and Select Station ID Screen do not appear in Display Mode.

1. From the main menu, place the cursor next to **USER/STATION ID**.
2. Press and release POWER ENTER RESET. The User and Station ID's Screen appears.



3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Autocal Values

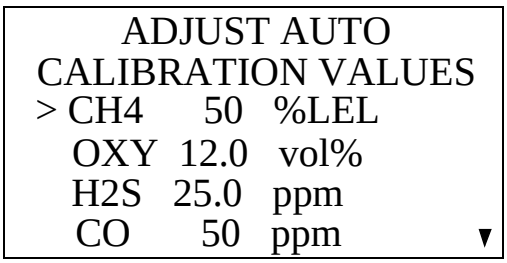
The EAGLE 2 stores calibration gas value settings. This allows you to calibrate all EAGLE 2 channels simultaneously with a calibration cylinder that contains all required target gases (for example the RKI 4-gas calibration cylinder).

The EAGLE 2 includes default auto calibration settings for most target gases. For gases without a default auto calibration value, the setting is 0.

NOTE: You can also update auto calibration settings in Calibration Mode. Updating the auto calibration gas values in Calibration Mode is normally done when performing a calibration. Updating these settings in Setup Mode allows you to update the settings without performing a calibration.

1. From the main menu, place the cursor next to **ADJ AUTOCAL VALUES**.

2. Press and release POWER ENTER RESET. The Adjust Auto Calibration Values Screen appears. The auto calibration value for each channel is shown.

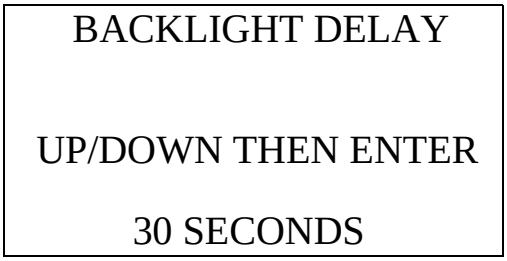


3. Use AIR ▲ YES or RANGE ▼SHIFT to place the cursor next to the auto calibration value you want to change.
4. Press and release POWER ENTER RESET. The auto calibration value begins to flash indicating it can be adjusted.
5. Use AIR ▲ YES and RANGE ▼SHIFT to adjust the auto calibration value to the desired value.
6. Press and release the POWER ENTER RESET button to accept the value.
7. Repeat Step 3 - Step 6 for each auto calibration value you want to change. If you want to return to the main menu at any time without saving any changes, press and release the DISPLAY ADJUST NO button until you return to the main menu.
8. Use RANGE ▼SHIFT to move the cursor next to the **END** menu item. Press and release the POWER ENTER RESET button to save the changes and return to the main menu.

Updating the Backlight Delay Setting

This setting indicates the length of time the LCD illuminates when you press any button. The minimum setting is 0 seconds; the maximum setting is 255 seconds. The factory setting is 30 seconds.

1. From the main menu, place the cursor next to **BACKLIGHT DELAY**.
2. Press and release POWER ENTER RESET. The Backlight Delay Screen appears.



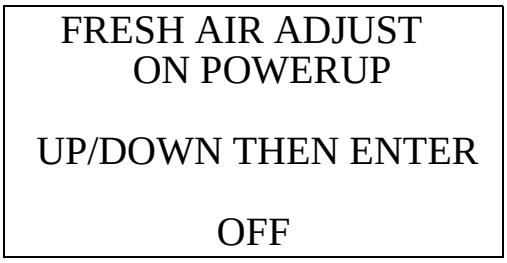
3. Use AIR ▲ YES and RANGE ▼ SHIFT to adjust the time to the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Auto Fresh Air Setting

This setting allows you to configure the EAGLE 2 so that a fresh air adjustment takes place automatically as part of the instrument startup sequence. If **AUTO FRESH AIR ADJ** is set to **ON**, the EAGLE 2 performs a fresh air adjustment at the end of the startup sequence before entering Normal Operation. The factory setting is **OFF**.

WARNING: If the automatic fresh air feature is turned on, you must startup the EAGLE 2 in a known fresh air environment, an environment free of toxic or combustible gases and of normal oxygen content (20.9%). If this feature is on and the EAGLE 2 is started up in the presence of a target gas, the readings and alarms will not be accurate or reliable.

1. From the main menu, place the cursor next to **AUTO FRESH AIR ADJ**.
2. Press and release POWER ENTER RESET. The Fresh Air Adjust Screen appears.



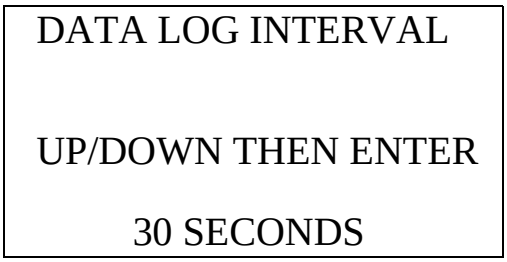
3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Data Log Interval Setting

This setting indicates how often the EAGLE 2 saves readings to the data logger. The following interval times can be selected: 10 minutes, 5 minutes, 3 minutes, 1 minute, 30 seconds, 20 seconds, 10 seconds, or 5 seconds. The factory setting is 30 seconds.

1. From the main menu, place the cursor next to **DATA LOG INTERVAL**.

2. Press and release POWER ENTER RESET. The Data Log Interval Screen appears.



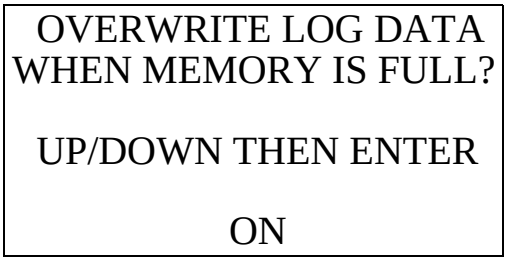
3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Data Log Overwrite Setting

With **DATA LOG OVERWRITE** set to **ON** (factory setting), the EAGLE 2 writes over the oldest data with new data when the data logger memory is full.

With **DATA LOG OVERWRITE** set to **OFF**, the EAGLE 2 stops saving data to the data logger when the data logger memory is full.

1. From the main menu, place the cursor next to **DATA LOG OVERWRITE**.
2. Press and release POWER ENTER RESET. The Overwrite Log Data Screen appears.



3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

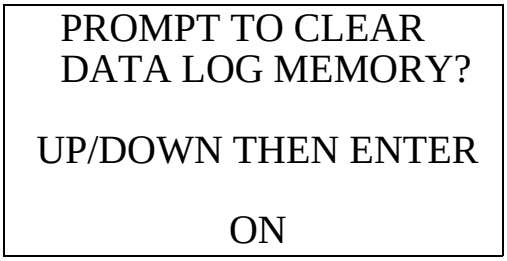
Updating the Data Log Memory Setting

With **DATA LOG MEMORY** set to **ON** (factory setting), the Data Logging Screen in Display Mode asks whether you want to clear the logged data in addition to showing the log time remaining (see “Data Logging Screen” on page 52).

With **DATA LOG MEMORY** set to **OFF**, the Data Logging Screen only

shows the remaining log time and does not give you the opportunity to clear the logged data.

1. From the main menu, place the cursor next to **DATA LOG MEMORY**.
2. Press and release POWER ENTER RESET. The Prompt to Clear Data Log Memory? Screen appears.

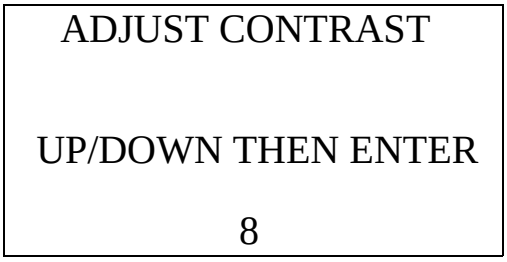


3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the LCD Contrast Setting

The contrast setting controls the LCD contrast. Select the setting so the characters on the display are easy to see. It can be set from 1 to 15. The factory setting is 8. The higher the setting, the darker the characters and LCD background.

1. From the main menu, place the cursor next to **ADJUST CONTRAST**.
2. Press and release POWER ENTER RESET. The Adjust Contrast Screen appears.

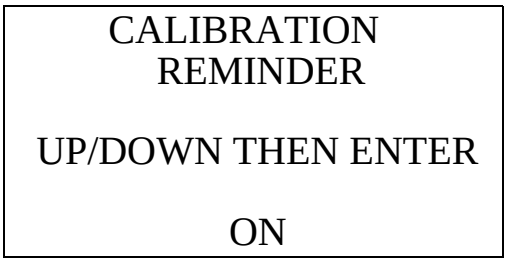


3. Use AIR ▲ YES or RANGE ▼ SHIFT to adjust the setting so that the characters on the LCD are easy to see.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Calibration Reminder Setting

With **CAL REMINDER** set to **ON** (factory setting), the EAGLE 2 will give an indication at start up if it is due for calibration. The type of indication will depend on the **CAL PAST DUE ACT** setting (see the next menu item below).

1. From the main menu, place the cursor next to **CAL REMINDER**.
2. Press and release POWER ENTER RESET. The Calibration Reminder Screen appears.



3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Calibration Past Due Action Setting

This item defines what indication is given during start up when calibration is due and **CAL REMINDER** is set to **ON**.

With **CAL PAST DUE ACT** set to **CONFIRM TO CAL** (factory setting), the EAGLE 2 will give an indication at start up if calibration is past due and require the user to decide whether to perform a calibration or continue and use the EAGLE 2 without calibrating. Press and release DISPLAY ADJUST NO to continue without calibrating or AIR ▲ YES to perform a calibration.

With **CAL PAST DUE ACT** set to **MUST CALIBRATE**, if the unit is due for calibration, the EAGLE 2 will give an indication at start up that calibration is past due and prompt you to press and release POWER ENTER RESET to enter Calibration Mode and perform a calibration. Using any other button will have no effect. A successful calibration must be performed in order to use the instrument.

With **CAL PAST DUE ACT** set to **NOTIFICATION ONLY,** the EAGLE 2 will give an indication at startup that calibration is past due. You must press and release POWER ENTER RESET to acknowledge the indication and proceed with the startup sequence.

1. From the main menu, place the cursor next to **CAL PAST DUE ACT**.

2. Press and release POWER ENTER RESET. The Calibration Past Due Action Screen appears.

CALIBRATION PAST DUE ACTION UP/DOWN THEN ENTER CONFIRM TO CAL

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Calibration Interval

This setting defines the amount of time between calibrations. The time can be set in 1 day increments. The minimum setting is 1 day and the maximum setting is 365 days. The factory setting is 90 days.

1. From the main menu, place the cursor next to **CAL INTERVAL**.
2. Press and release POWER ENTER RESET. The Set Calibration Interval Screen appears.

SET CALIBRATION INTERVAL UP/DOWN THEN ENTER 90 DAYS

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.

Tip: Press and hold AIR ▲ YES or RANGE ▼ SHIFT to rapidly scroll through the settings.

4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating LC/BH Mode Setting

With **LC/BH MODE SELECT** set to **LC & BH**, the Mode Select Screen appears when the unit is turned on. You are able to select from Normal Mode, Leak Check Mode, and Bar Hole Mode.

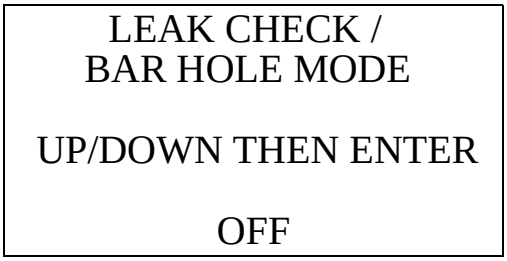
With **LC/BH MODE SELECT** set to **BAR HOLE ONLY**, the Mode Select Screen appears when the unit is turned on. You are able to select from Normal Mode and Bar Hole Mode.

With **LC/BH MODE SELECT** set to **LEAK CHECK ONLY**, the Mode Select Screen appears when the unit is turned on. You are able to select from Normal Mode and Leak Check Mode.

With **LC/BH MODE SELECT** set to **OFF**, the Mode Select Screen does not appear when the unit is turned on and the unit goes into Normal Mode after the start up sequence.

This setting is factory set to **OFF** when a unit is shipped unless the instrument is ordered for bar hole measurement or leak checking use. See "Appendix K: Using the EAGLE 2 in Bar Hole Mode" and "Appendix L: Using the EAGLE 2 in Leak Check Mode" for discussions of Bar Hole Mode and Leak Check Mode, respectively.

1. From the main menu, place the cursor next to **LC/BH MODE SELECT.**
2. Press and release POWER ENTER RESET. The Leak Check/Bar Hole Mode Screen appears.

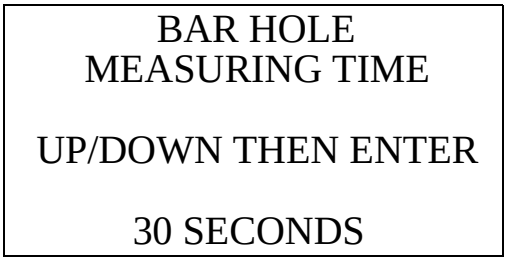


3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Setting the Bar Hole Measurement Time

This setting indicates the length of time the unit will sample when a bar hole measurement is initiated in Bar Hole Mode. It can be set to 30 (factory setting), 45, or 60 seconds.

1. From the main menu, place the cursor next to **BH MEASURING TIME.**
2. Press and release POWER ENTER RESET. The Bar Hole Measuring Time Screen appears.



3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.

4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Zero Follower Settings

The **ZERO FOLLOWER** setting is not intended for field adjustment. The default setting for most target gases is **ON**. The default setting for carbon dioxide channels and some configurations of non-standard toxic gas channels is **OFF**. The oxygen channel does not support this feature.

Zero Suppression Settings

The **ZERO SUPRESSION** setting is not intended for field adjustment. The typical setting is 2% of full scale. The oxygen channel does not support this feature.

Updating the Confirmation Alert Setting

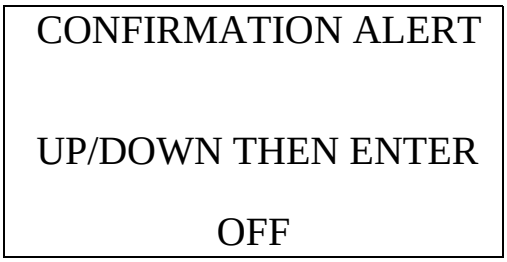
With **CONFIRMATION ALERT** set to **BEEP AND LIGHT**, the EAGLE 2 beeps and flashes the LED arrays once every 15 minutes to verify that it is operating.

With **CONFIRMATION ALERT** set to **LIGHT ONLY**, the EAGLE 2 flashes the LED arrays once every 15 minutes to verify that it is operating.

With **CONFIRMATION ALERT** set to **BEEP ONLY**, the EAGLE 2 beeps once every 15 minutes to verify that it is operating.

With **CONFIRMATION ALERT** set to **OFF** (factory setting), the EAGLE 2 does not sound a confirmation alert.

1. From the main menu, place the cursor next to **CONFIRMATION ALERT.**
2. Press and release POWER ENTER RESET. The Confirmation Alert Screen appears.



3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Turning the Password Function On or Off

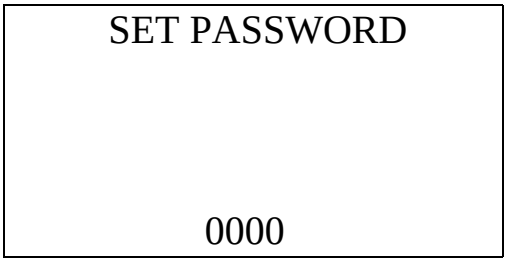
With **CHANGE PASSWORD** set to **ON**, the EAGLE 2 prompts you for a password when you enter Calibration Mode or Setup Mode.

With **CHANGE PASSWORD** set to **OFF** (factory setting), no password is required to enter Calibration Mode or Setup Mode.

1. From the main menu, place the cursor in front of **CHANGE PASSWORD**.
2. Press and release POWER ENTER RESET. The Password Protection Screen appears.

3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. If you selected **OFF,** press and release POWER ENTER RESET to save the setting and return to the main menu.

   If you selected **ON**, continue with Step 5.
5. Press and release POWER ENTER RESET. The Set Password Screen appears. The factory set pass password of 0000 is at the bottom of the screen with the first 0 flashing.



6. Use AIR ▲ YES or RANGE ▼ SHIFT to display a number from 0 to 9.
7. Press and release POWER ENTER RESET to enter the selection and advance to the next number.
8. Repeat Step 6 and Step 7 to select the remaining numbers. When you press and release POWER ENTER RESET to enter the last number, the password is saved and you return to the main menu.

Restoring the Default Settings

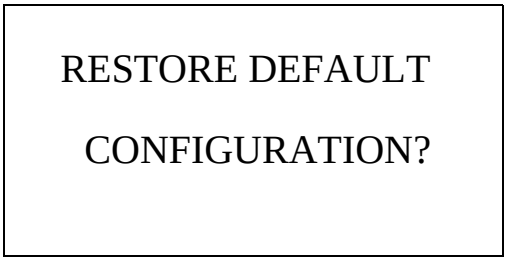
Each of the EAGLE 2 setup parameters, such as the auto calibration values, zero and span settings, or parameters in Setup Mode, has a default setting. For the items in Setup Mode, the default settings are the same as the standard factory settings. If you want to return the EAGLE 2 to its default configuration, it is possible to do so by using the Default Settings menu item in Setup Mode. Returning the EAGLE 2 to its default configuration can be useful if various setup parameters have been changed in the field and you want to return the EAGLE 2 to its original configuration as shipped from the factory.

The standard default gas configuration is LEL / oxygen / H_2S / CO. If you have turned any channels off or have added channels to your EAGLE 2, you will have to re-setup your EAGLE 2 to the desired gas combination if you restore the EAGLE 2 to its default configuration.

There are some special EAGLE 2 configurations that may have a different default configuration than the standard. Consult RKI Instruments, Inc. for information regarding non-standard default configurations.

WARNING: When the EAGLE 2 is restored to its default configuration, the zero and span values for each channel are reset. You must recalibrate all active channels if you restore the EAGLE 2 to its default configuration.

1. From the main menu, place the cursor in front of **DEFAULT SETTINGS**.
2. Press and release POWER ENTER RESET. The Restore Default Configuration? Screen appears asking if you want to restore the default configuration.

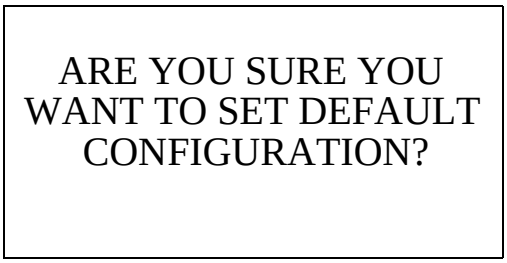


3. If you do not want to restore the default configuration**,** press and release DISPLAY ADJUST NO to return to the main menu.

   If you do want to restore the default configuration, continue with Step 4.

4. Press and release AIR ▲ YES. A screen appears asking you to confirm

that you want to restore the default configuration.



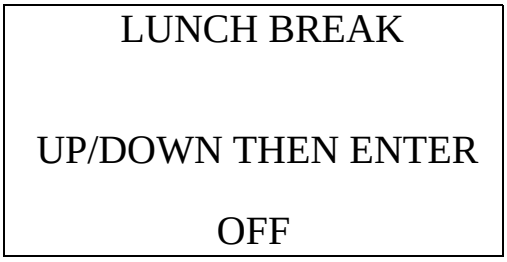
5. Press and release AIR ▲ YES. The screen will indicate that the default configuration has been restored and return to the main menu.

Updating the Lunch Break Setting

With **LUNCH BREAK** set to **OFF** (factory setting), the EAGLE 2 automatically starts new TWA and PEAK reading collection and resets the time in operation at startup.

With **LUNCH BREAK** set to **ON**, the Resume Measurements Screen displays during startup. From this screen, you can choose to continue accumulating TWA and PEAK readings and the time in operation from the last time the EAGLE 2 was used or start collecting new readings and reset the time in operation.

1. From the main menu, place the cursor next to **LUNCH BREAK.**
2. Press and release POWER ENTER RESET. The Lunch Break Screen appears.



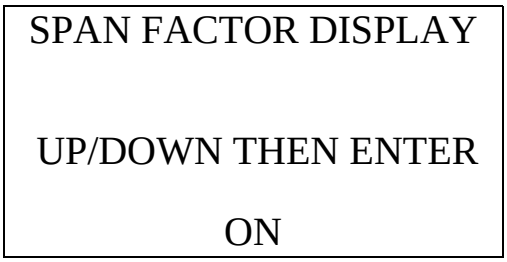
3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Span Factor Setting

With **SPAN FACTOR** set to **ON** (factory setting), the EAGLE 2 will display the span adjustment range for a sensor in the calibration results screen while in Single Calibration. The span adjustment shows how low and how high the reading could have been adjusted.

With **SPAN FACTOR** set to **OFF**, this span adjustment does not appear in the calibration results screen.

1. From the main menu, place the cursor next to **SPAN FACTOR**.
2. Press and release POWER ENTER RESET. The Span Factor Screen appears.



3. Use AIR ▲ YES or RANGE ▼ SHIFT to display the desired setting.
4. Press and release POWER ENTER RESET to save the setting and return to the main menu.

Updating the Language Setting

This setting allows you to select the language for the EAGLE 2's user interface. The available choices are English (factory setting), Spanish, French, Italian, and German.

1. From the main menu, place the cursor next to **SELECT LANGUAGE.**
2. Press and release POWER ENTER RESET. The Select Language Screen appears with the cursor in front of the current language.

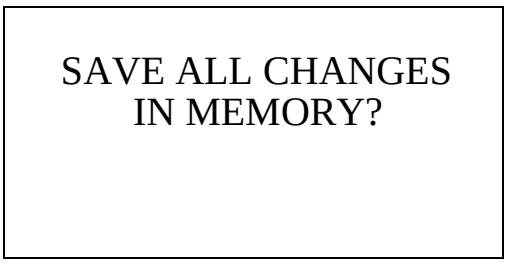
3. Use AIR ▲ YES or RANGE ▼ SHIFT to move the cursor in front of the desired language.

   If you do not wish to select a new language, either press and release DISPLAY ADJUST NO or move the cursor all the way to the bottom of the list in front of **END** and press and release POWER ENTER RESET. The unit will return to the main menu.
4. Press and release POWER ENTER RESET to save the new language setting and return to the main menu. The EAGLE 2's user interface will now be in the newly selected language.

NOTE: If you select a language other than English, a prompt will appear during startup that allows you to change the language back to English if desired.

Exiting Setup Mode

1. From the main menu, place the cursor in front of **NORMAL OPERATION** at the bottom of the menu.
2. Press and release POWER ENTER RESET.
3. A screen appears that asks if you want to save the changes you have made.



NOTE: If you entered Setup Mode and did not make any changes, the above screen will still appear. In this case, press and release DISPLAY ADJUST NO to proceed to exit Setup Mode and begin the EAGLE 2's startup sequence.

4. If you do not want to save the changes, press and release DISPLAY ADJUST NO. The unit will begin its startup sequence without saving the changes.

   If you do want to save the changes, press and release AIR ▲ YES and continue with the next step.

5. A confirmation screen appears asking if you are sure you want to save the changes.

6. If you want to save the changes, press and release AIR ▲ YES to save the changes. A screen will appear for a few seconds indicating that the changes have been saved and the unit will begin its start-up sequence.

   If you do not want to save the changes, press and release DISPLAY ADJUST NO to proceed to the unit's start-up sequence without saving changes.

Appendix C: Sub PCBs

Overview

An EAGLE 2 that has one or more of the standard four sensors, catalytic LEL, oxygen, H_2S, and CO, and no optional sensors does not have any sub PCBs installed. The sub PCBs are used to add circuitry to the EAGLE 2 that supports various optional sensors. An EAGLE 2 has provisions to install up to three sub PCBs. Although an EAGLE 2 with three sub PCBs installed can theoretically support seven sensors if you include the standard four sensors, the EAGLE 2 is only capable of having six active channels.

Description

The main PCB can accept up to three sub PCBs. The sub PCBs are installed below a row of connectors near the top of the main PCB. The three positions are labeled on the main PCB silkscreen from right to left as SUB1, SUB2, and SUB3. These labels are not visible when the sub PCBs are installed.

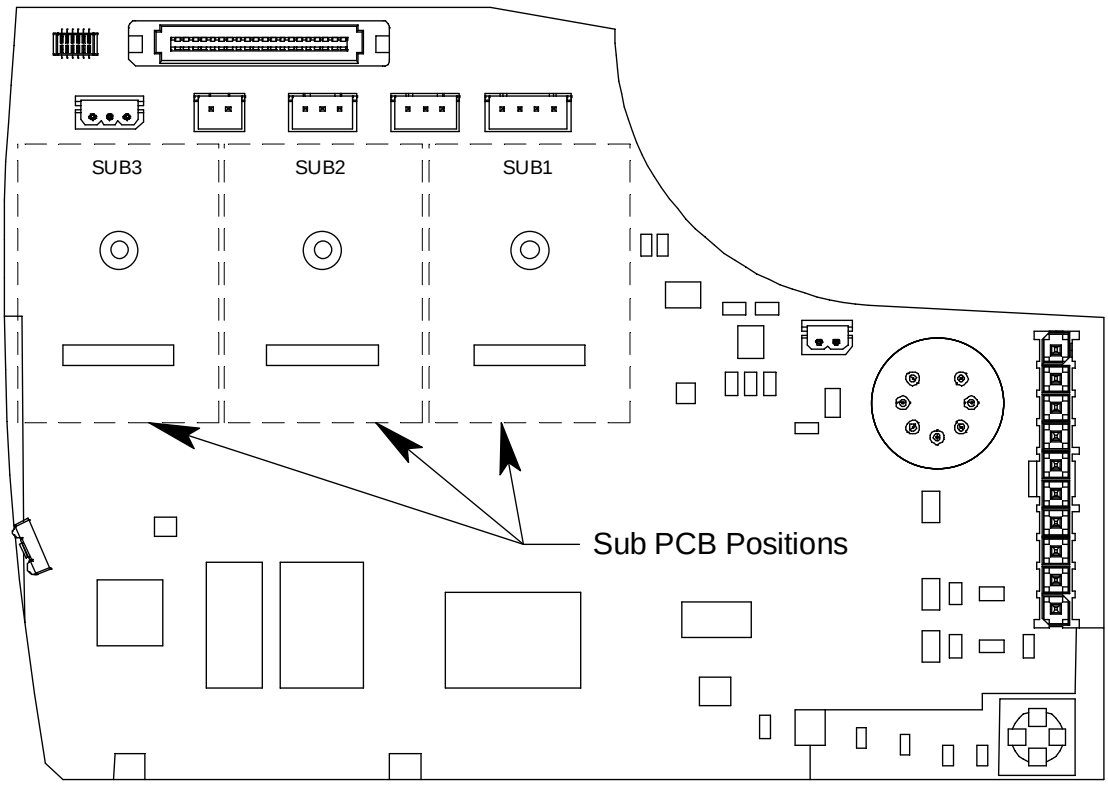


Figure 25: Sub PCB Positions

The sub PCBs plug into the main PCB with a multiposition connector and are retained in place with a screw / flat washer / lock washer. Any sub PCB can be installed in any of the sub PCB positions. A sensor that is supported by a sub PCB connects to that sub PCB with a cable. There are four types of sub PCBs, each supporting one type of optional sensor:

- The PID sub PCB supports a low range or a high range PID (photo ionization detector) sensor.
- The ESM-01 sub PCB supports any of the ESM-01 family toxic sensors.
- The TC sub PCB supports the EAGLE 2 TC (thermal conductivity) sensor.
- The Infrared (IR) sub PCB supports any of the EAGLE 2 IR sensors for combustible gas or CO_2.

There are no user serviceable parts on the sub PCBs.

Channel Setup & Sub PCBs

When a sub PCB is installed in a particular location, it is reflected in the CONFIGURE CHANNELS and CONFIGURE GASES menu items in Setup Mode.

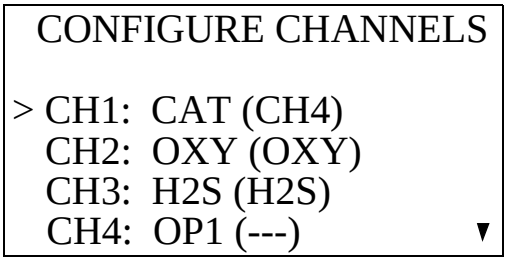
Sub PCBs and CONFIGURE CHANNELS

A channel configured as an optional sensor type supported by a sub PCB is indicated by OP1, OP2, or OP3, specifying which sub PCB position is mapped to that channel. OP1 indicates a channel supported by the SUB1 PCB, OP2 indicates a channel supported by the SUB2 PCB, and OP3 indicates a channel supported by the SUB3 PCB. The example LCD screen below illustrates the first screen in the CONFIGURE CHANNELS menu item in Setup Mode and shows a channel configuration for LEL catalytic, oxygen, H_2S, and a PID sensor with the sub PCB for the PID sensor installed in location SUB1.

```
  CONFIGURE CHANNELS

> CH1:  CAT (CH4)
  CH2:  OXY (OXY)
  CH3:  H2S (H2S)
  CH4:  OP1 (PID)          ▼
```

If you configure a channel as an optional type that is mapped to a sub

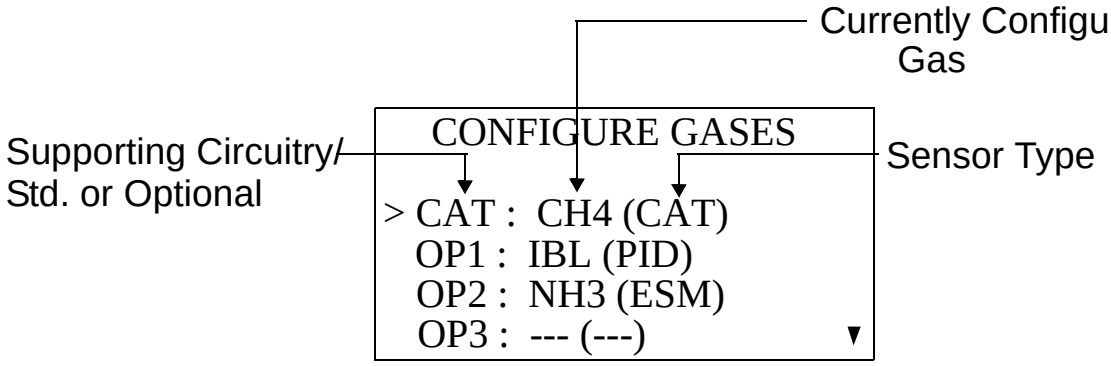
PCB position that has no sub PCB installed, the channel will be undefined and that channel will indicate a sensor failure during the startup sequence. The CONFIGURE CHANNELS LCD screen below illustrates this situation.



The "---" to the right of OP1 indicates that no sub PCB is installed in position SUB1. See "Configuring the Channels" on page 101 for a complete description of the CONFIGURE CHANNELS Setup Mode menu item.

Sub PCBs and CONFIGURE GASES

The CONFIGURE GASES menu item in Setup Mode allows you to configure the gas for a catalytic, TC, or PID sensor that is installed. There are four possible sensors that can be configured depending on the particular version of the EAGLE 2. The LCD screen below illustrates the first screen in the CONFIGURE GASES menu item in Setup Mode.



The four possible sensors are a catalytic sensor and three optional sensors. They are listed with the following information from left to right:

- The circuitry that supports the sensor and whether it is standard or optional

  This can be the catalytic circuit on the main PCB indicated by CAT or one of the sub PCBs indicated by OP1 (option 1), OP2 (option 2), and OP3 (option 3). OP1 indicates that the SUB1 PCB supports the sensor, OP2 indicates that the SUB2 PCB supports the sensor, and

OP3 indicates that the SUB3 PCB supports the sensor. The OP1, OP2, and OP3 identifiers also indicate that the sensor is an optional sensor. The catalytic sensor is a standard sensor. Each of these is always listed.

- The currently configured gas
  The catalytic sensor is always defined and configured even if it is not setup as active in CONFIGURE CHANNELS. If any of the Sub PCBs are not installed, then the corresponding sensor is undefined and the next two fields are filled with dashes (---). In the example above, the catalytic sensor is configured as methane (CH_4), the sensor supported by the SUB1 PCB is configured as isobutylene (IBL), the sensor supported by the SUB2 PCB is configured as ammonia (NH_3), and there is no sub PCB installed in position SUB3.

- The sensor type
  The sensor type can be one of the following: catalytic (CAT), photo ionization detector (PID), ESM-01 toxic (ESM), infrared (IR), or thermal conductivity (TC). Although any installed sensor type will be listed in CONFIGURE GASES, the only sensor types whose gas can be configured are catalytic, PID, and TC sensor types.

  If you select an ESM-01 toxic or IR type of sensor to configure in this menu item, a message will appear indicating that the gas configuration for this sensor is automatically detected by the EAGLE 2 and that manual configuration is not possible. Both of these sensor types have the gas configuration stored in memory onboard the sensor.

ESM & IR SENSOR ARE AUTOMATICALLY DETECTED. MANUAL SELECTION IS NOT POSSIBLE

See the appropriate optional sensor appendix for a complete description of configuring the gas for that type of sensor.

Appendix D: PID Sensors

Overview

The PID (photo ionization detector) sensors are used for applications where high sensitivity is needed to monitor ppm levels of VOCs (volatile organic compounds). This appendix describes the EAGLE 2's PID sensors and includes instructions to use an EAGLE 2 that has a PID sensor installed. It also includes instructions to maintain and replace a PID sensor.

Table 13: EAGLE 2 PID Sensor Specifications

Target Gas	Sensor Type	Detection Range	Reading Increment	Alarm 1 Factory Setting	Alarm 2 Factory Setting
VOCs, Isobutylene Calibration Standard	Low Range	0 - 50.00 ppm	0.02 ppm	5.00 ppm	10.00 ppm
	High Range	0 - 2000 ppm	1 ppm	400 ppm	1000 ppm

Description

Two types of PID sensors can be used with the EAGLE 2, a low range (high sensitivity) sensor and a high range (low sensitivity) sensor (see Table 13 for specifications). The PID sensor is installed in a single sensor flow chamber which is located in the area next to the standard 4-sensor flow chamber. This area can accommodate up to three single sensor flow chambers. Figure 26 below illustrates a typical PID sensor location in front of the pump. The PID flow chamber may also be installed in one of the other two sensor chamber locations depending on the particular version of the EAGLE 2. Some PID instrument configurations do not include the 4-sensor flow chamber.

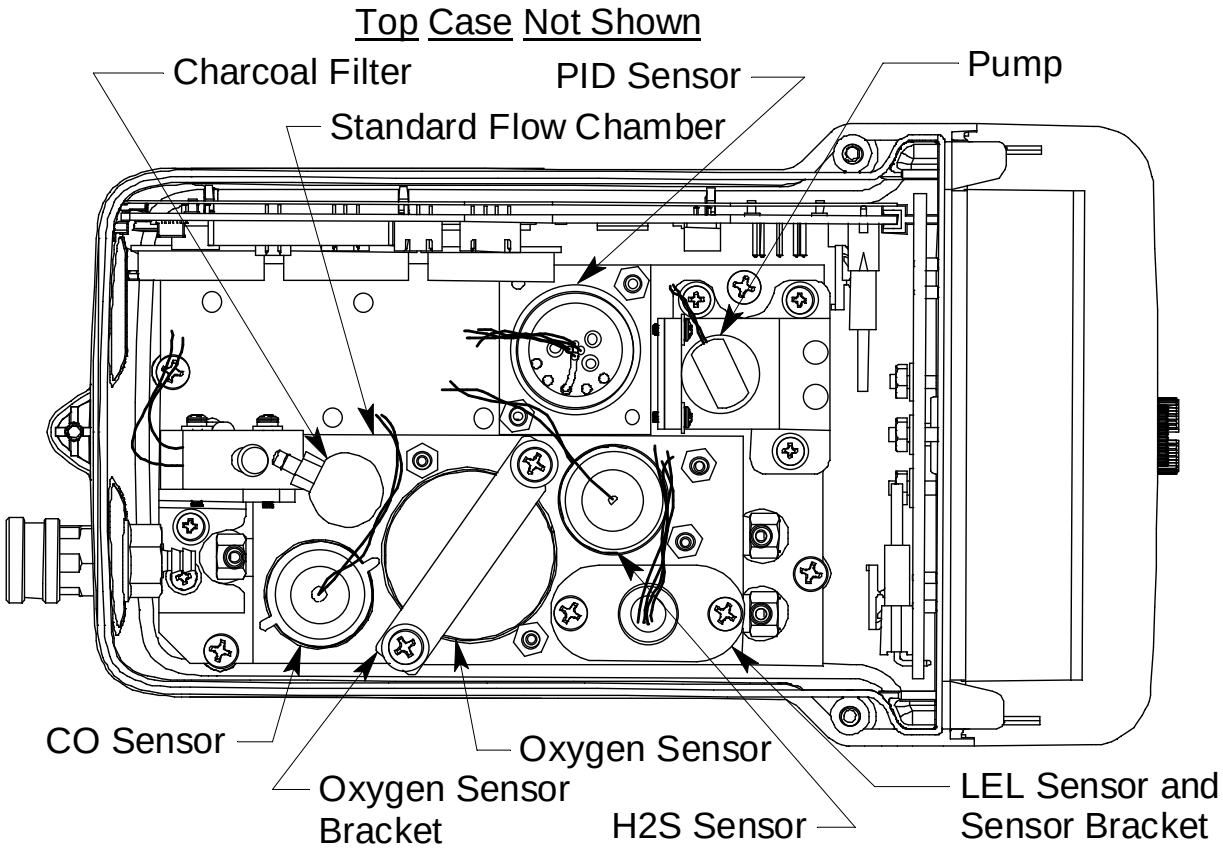


Figure 26: Typical PID Sensor Location

PID Sensor & Sensor Adapter

The PID sensor is a cylindrical sensor with a diffusion opening on the front and 3 pins on the back. It is plugged into a sensor adapter with a 5 wire cable that terminates in a 5-position connector. The connector plugs into a PID sub PCB (see description below) that is installed on the main PCB. The sensor adapter allows installation of the PID sensor into the PID flow chamber. The sensor adapter is held in the PID flow chamber with two O-rings which also seal around the sensor adapter.

PID Sub PCB

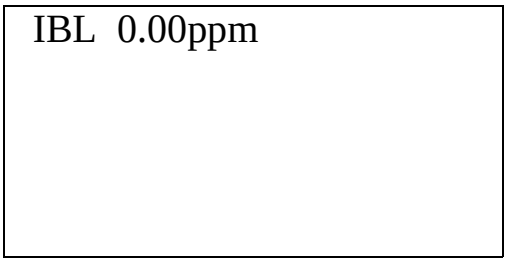
The PID sub PCB is a circuit board that is installed on the main PCB in one of the 3 sub PCB positions when a PID sensor is used with the EAGLE 2. The PID sensor adapter connects to the sub PCB with a 5-position connector. The sub PCB plugs into the main PCB and is held in place with a screw / flat washer / lock washer. There are no user serviceable parts on the PID sub PCB.

Start Up and Normal Operation

For instructions to startup and use an EAGLE 2 that includes a PID sensor, reference “Start Up” on page 22, “Measuring Mode, Normal Operation” on page 29, and “Measuring Mode, Alarms” on page 34. Follow these instructions keeping the following special considerations in mind:

- Several of the gases that can be monitored with a PID are easily absorbed in the EAGLE 2’s standard sample hose. One example of this is styrene. Because of this, RKI Instruments, Inc. recommends that you install the probe directly to the inlet fitting when monitoring for gas with the PID sensor. If it is necessary to use a sample hose for any reason, you must use the teflon lined hose that is supplied with the PID instrument. A 5 foot hose is supplied as standard. 10, 15, and 20 foot hoses are also available. See the Parts List at the end of this appendix for ordering information.
- If your EAGLE 2 is a multigas unit that is used for monitoring of combustible gases in the %LEL range, the PID channel will indicate an upscale reading if these gases are present. If %LEL concentrations of combustible gas are present, the PID channel may indicate an overscale reading.
- The PID sensor will also respond to H_2S, so if H_2S is present, the PID channel may indicate an upscale reading depending on the concentration present.

The standard calibration for a PID channel is to isobutylene. A PID channel can be factory setup for and calibrated to other gases. Consult RKI Instruments, Inc. for other available PID configurations and to specify the desired PID configuration when a unit is ordered. The display screen below illustrates an EAGLE 2 with a low range PID sensor installed.



It is possible to temporarily configure a PID channel for a target gas other than the factory setting in Display Mode. See the next section, “PID Relative Response Feature”, for instructions to use this feature.

PID Relative Response Feature

The relative response feature enables you to change the PID sensor's response to gas on the fly so that the PID channel is roughly calibrated to an alternate gas. This is done by temporarily changing the gas configuration of the PID channel. You can select from a list of gases whose response relative to the configured gas, normally isobutylene, is programmed into the EAGLE 2's memory. For example, if the PID channel is setup for and calibrated to isobutylene (IBL), you can select isopropyl alcohol (IPA) from a gas list accessible from the PID Relative Response Screen in Display Mode so that the PID channel responds to gas as if it were calibrated to isopropyl alcohol. The EAGLE 2 will clear the gas configuration change when it is turned off and will return to the programmed configuration when it is turned on again.

The gas list for the relative response feature includes several pre-defined gases and 1 gas that can be entered into the EAGLE 2 in the field using the Eagle 2 Maintenance Data Loader Program. The Eagle 2 Maintenance Data Loader Program Operator's Manual contains a chart of response factors relative to isobutylene for many gases. If the desired gas is not in this chart, gas testing must be performed to determine the gas' response factor relative to isobutylene. See the Eagle 2 Maintenance Data Loader Program Operator's manual for details regarding the gas testing and programming user defined gases into the EAGLE 2's relative response list.

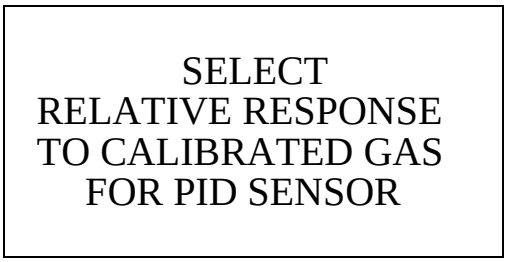
Because of normal variation between sensors, these relative response factors are typical factors. If you use this feature, the response to the selected gas will not be as accurate as it would be if you configured and calibrated the PID channel to the target gas.

For maximum accuracy, configure and calibrate the EAGLE 2's PID channel to the desired target gas.

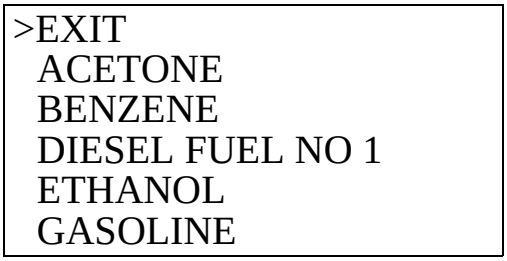
PID Sensor Relative Response Screen in Display Mode

To use the relative response feature for the PID sensor, enter display mode and select the desired gas as described below:

1. With the EAGLE 2 in Measuring Mode, press and release the DISPLAY ADJUST NO button repeatedly until you arrive at the PID Sensor Relative Response Screen.



2. With the PID Sensor Relative Response Screen displayed, press and release AIR ▲ YES. A list of gases will appear on the screen with **EXIT** at the top of the list.



There are multiple screens of gases. The following is the complete list of factory defined gases along with their detection ranges, low alarm, high alarm, STEL, and TWA settings. Table 14 is a list of the low range values and Table 15 is a list of the high range values.

Table 14: Low Range Relative Response Gas List

Target Gas	Detection Range (ppm)	Alarm 1 Factory Setting (ppm)	Alarm 2 Factory Setting (ppm)	STEL (ppm)	TWA (ppm)
Acetone	0-30.00	5.00	7.50	OFF	OFF
Benzene	0-25.00	0.50	2.50	2.50	0.50
Diesel Fuel NO 1	0-40.00	2.00	3.00	OFF	OFF
Ethanol	0-400.00	10.0	15.0	OFF	OFF
Gasoline	0-50.00	3.00	5.00	OFF	OFF
Isobutylene	0-50.00	4.30	6.00	OFF	OFF
Isopropanol	0-200.00	2.0	4.0	OFF	OFF
JP-5 Fuel	0-30.00	1.40	2.10	OFF	OFF
Methyl Ethyl Ketone	0-40.00	2.00	3.00	OFF	OFF
Toluene	0-25.00	0.50	1.50	OFF	OFF
N-Hexane	0-200.00	5.0	10.0	OFF	OFF
Propylene	0-50.00	5.00	7.50	OFF	OFF
Styrene	0-20.00	0.20	0.40	OFF	OFF
Tetrachloro-ethylene	0-30.00	0.24	1.00	OFF	OFF
Trichloro-ethylene	0-30.00	0.50	1.00	OFF	OFF
Vinyl Chloride	0-100.00	1.0	5.0	5.0	1.0
PID	0-50.00	OFF	OFF	OFF	OFF

Table 15: High Range Relative Response Gas List

Target Gas	Detection Range (ppm)	Alarm 1 Factory Setting (ppm)	Alarm 2 Factory Setting (ppm)	STEL (ppm)	TWA (ppm)
Acetone	0-1000	500	750	750	500
Benzene	0-1000	50	250	OFF	OFF
Diesel Fuel NO 1	0-1500	200	300	OFF	200
Ethanol	0-15000	1000	1500	OFF	1000
Gasoline	0-2000	300	500	500	300

Isobutylene	0-2000	400	600	60	42
Isopropanol	0-5000	200	400	400	200
JP-5 Fuel	0-1000	140	210	OFF	14
Methyl Ethyl Ketone	0-1500	200	300	300	200
Toluene	0-1000	50	150	150	50
N-Hexane	0-5000	500	1000	1000	500
Propylene	0-2500	500	750	OFF	500
Styrene	0-500	20	40	40	20
Tetrachloro-ethylene	0-1000	25	100	100	25
Trichloro-ethylene	0-1000	50	100	100	50
Vinyl Chloride	0-4000	100	500	OFF	OFF
PID	0-2000	OFF	OFF	OFF	OFF

The last choice in each list, PID, can be defined by the user and loaded in the EAGLE 2 using the Eagle 2 Maintenance Data Loader Program. See the Eagle 2 Maintenance Data Loader Program Operator's Manual.

3. Use the AIR ▲ YES or RANGE ▼ SHIFT button to move the cursor next to the desired gas.
4. Press and release POWER ENTER RESET. The PID channel will be configured to the selected gas and the EAGLE 2 will proceed to the STEL Screen. This configuration will be in force until either a different gas is selected in Display Mode or the unit is turned off.

PID Calibration

A PID channel can be calibrated using the auto calibration method or the single calibration method. To calibrate a PID channel using the single calibration method, see "Calibrating Using the Single Calibration Method" on page 63 and follow the instructions for calibrating a single channel.

NOTE: The factory setting for the Span Factor menu item in Setup Mode is OFF for an EAGLE 2 with a PID channel. So the range of adjustment is not displayed when a single calibration is performed for any channel if a PID sensor is installed.

If your instrument is a multi-channel instrument that includes a PID channel, RKI Instruments, Inc. recommends using the auto calibration method for convenience. The calibration instructions below show a 5 channel instrument which has the four standard channels, LEL / oxygen / H_2S / CO, and a PID channel calibrated and setup for isobutylene (IBL). To use the auto calibration method to calibrate a multi-channel instrument that includes a PID channel, do the following:

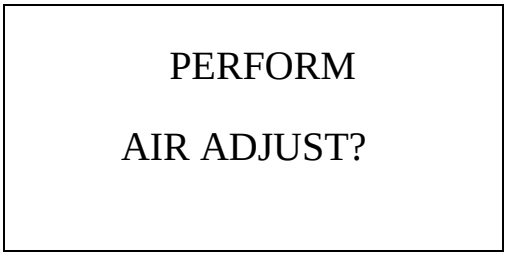
1. See "Calibration Supplies and Equipment" on page 56 for a description of the necessary calibration supplies. In addition to an appropriate multi-gas cylinder that is used to calibrate any active standard channels, you will also need a cylinder to calibrate the PID channel. See Table 17 on page 164 for available cylinders. Make sure your calibration cylinder is appropriate for the PID detection range.
2. Find a fresh-air environment. This is an environment free of toxic or combustible gases and of normal oxygen content (20.9%).
3. While in Measuring Mode, press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both buttons.
4. If the unit prompts you for the password, enter it by using the AIR ▲ YES and RANGE ▼ SHIFT buttons to select each password number and then pressing and releasing POWER ENTER RESET to enter the number and move on to the next one.
5. The Calibration Mode Screen displays with the cursor next to **AUTO CALIBRATION**.

```
CALIBRATION MODE

> AUTO CALIBRATION
  SINGLE CALIBRATION
  PERFORM AIR ADJUST
  NORMAL OPERATION
```

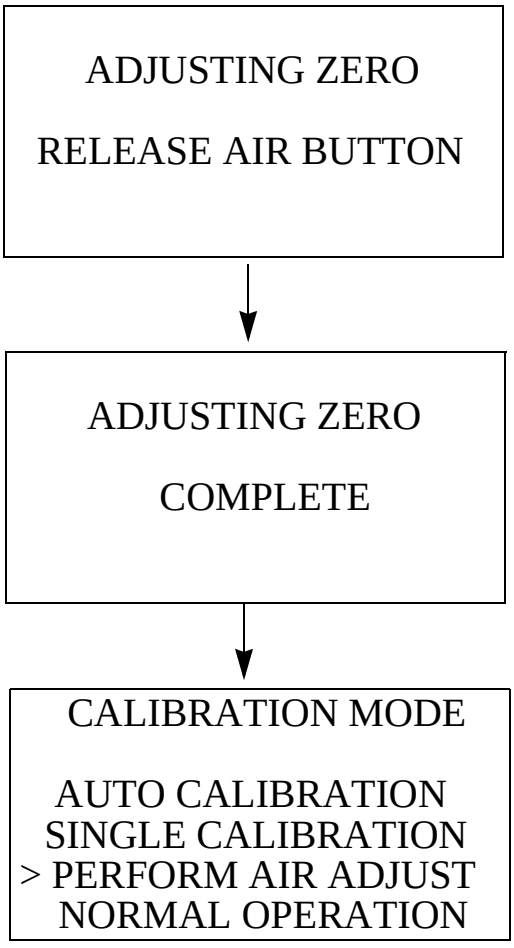
6. Move the cursor to the **PERFORM AIR ADJUST** menu item by using the RANGE ▼ SHIFT button.

```
CALIBRATION MODE

  AUTO CALIBRATION
  SINGLE CALIBRATION
> PERFORM AIR ADJUST
  NORMAL OPERATION
```

7. Press and release the POWER ENTER RESET button. The following screen appears.



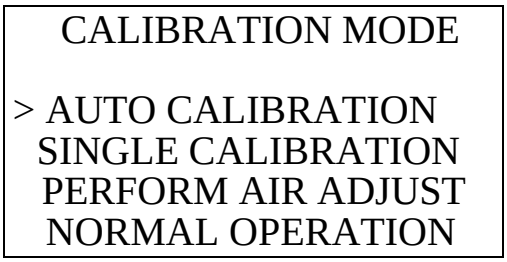
8. Press and release the AIR ▲ YES button to continue.
   If you do not want to continue, press the DISPLAY ADJUST NO button and the unit will return to the Calibration Mode Screen.
9. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.



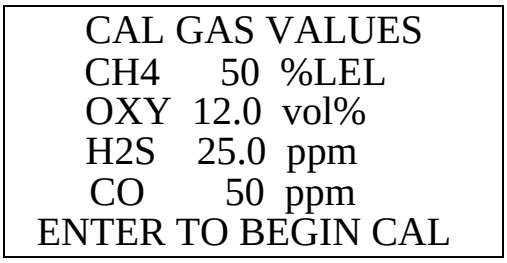
10. Install the demand flow regulator onto the multi-gas calibration cylinder.
11. Connect the sample tubing to the demand flow regulator.
12. Install the probe on the EAGLE 2 inlet fitting. Make sure the probe is complete with internal O-ring and membrane and that the two halves of

the probe are tightened firmly together to avoid leaks that can affect the calibration. See Figure 20, “Replacing the Hydrophobic Filter Disk & O-ring” on page 73 for an illustration of the internal parts of the probe.

13. Move the cursor next to the **AUTO CALIBRATION** menu item by using the AIR ▲ YES button.



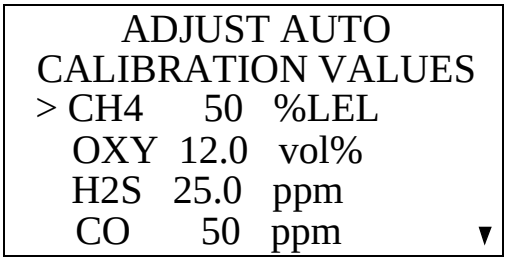
14. Press and release the POWER ENTER RESET button to display the Calibration Gas Values Screen.



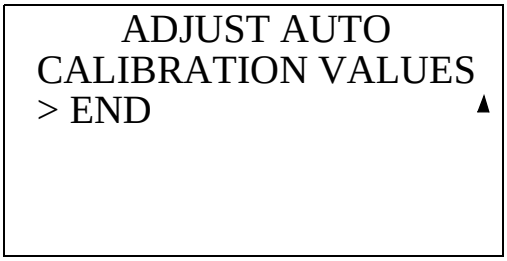
The gas concentrations displayed in the Calibration Gas Values Screen must match the gas concentrations listed on the 4-gas calibration cylinder.
If *all* concentrations match, go to Step 25.
If *one or more* concentrations *do not* match, continue with Step 15.
If you do not want to continue with the calibration, press and release the DISPLAY ADJUST NO button to return to the Calibration Mode Screen.

NOTE: The RKI 4-gas cylinder typically contains 12% O_2 by volume. When using the auto calibration method, be sure to set the “OXY” auto calibration value to agree with the concentration listed on the cylinder’s label, not zero.

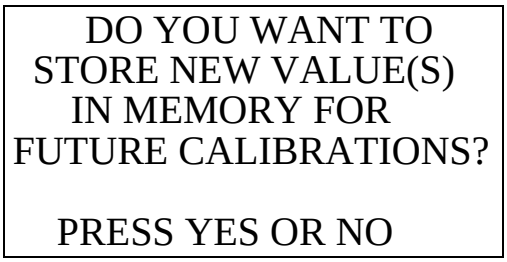
15. To adjust the values on the screen, press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both. The following screen appears with the cursor next to **CH4**.



16. Place the cursor next to the channel whose gas value you want to change using the AIR ▲ YES and RANGE ▼ SHIFT buttons.
17. Press and release the POWER ENTER RESET button to select the channel. The calibration gas value begins to flash.
18. Use the AIR ▲ YES and RANGE ▼ SHIFT buttons to adjust the calibration gas setting to the desired value.
19. Press and release the POWER ENTER RESET button to save the change. The calibration gas value stops flashing.
20. Repeat Step 15 through Step 19 for any other channels that need to be changed.
21. When you are done adjusting the calibration gas values, move the cursor down past the bottom of the screen next to **END**.



22. Press and release the POWER ENTER RESET button. The following screen appears.



23. If you select YES by pressing and releasing the AIR ▲ YES button, the changes that you made will be saved in the EAGLE 2's memory as the new auto calibration gas values.

    If you select NO by pressing and releasing the DISPLAY ADJUST NO button, the changes you made will be used for any calibrations performed during the current operating session only. The EAGLE 2 will delete the changes when the unit is turned off and will load the previous set of auto calibration values when it is turned on again.

24. When you make your selection and press the desired button, the unit returns to the Calibration Gas Values Screen.

CAL GAS VALUES
CH4 50 %LEL
OXY 12.0 vol%
H2S 25.0 ppm
CO 50 ppm
ENTER TO BEGIN CAL

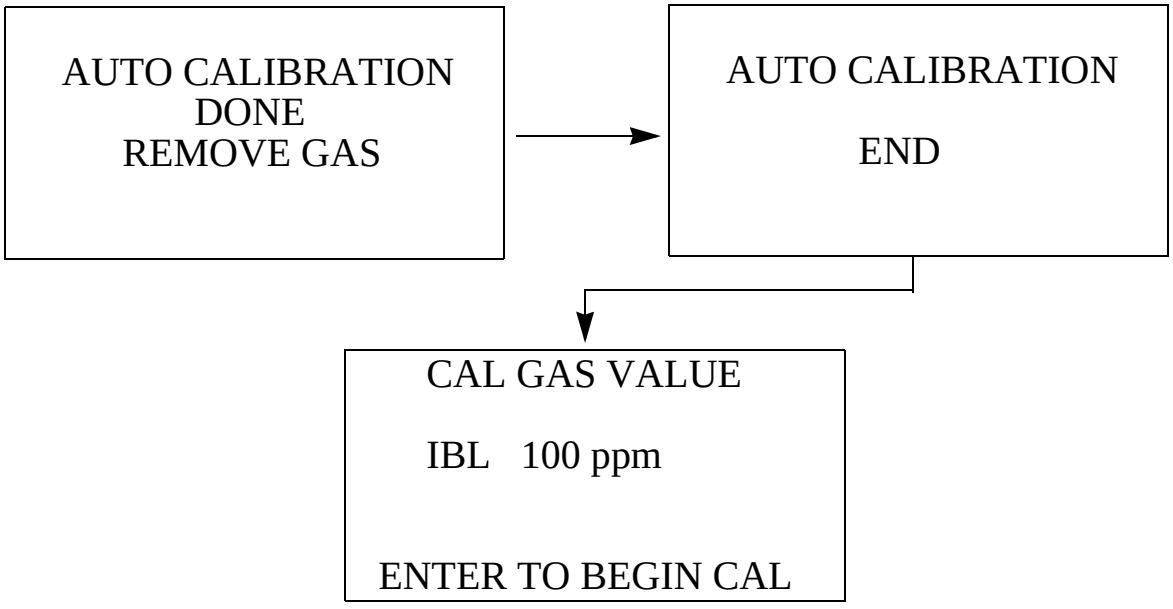
25. Press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen with **CAL IN PROCESS** flashing.

CAL IN PROCESS
CH4 0 %LEL
OXY 20.9 vol%
H2S 0.0 ppm
CO 0 ppm
ENTER WHEN DONE

If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the Cal Gas Values Screen.

If you do want to continue with the calibration, proceed to the next step.

26. Connect the tubing from the demand flow regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for one minute.
27. Press and release the POWER ENTER RESET button to set the span adjustment for each channel to the programmed values.
28. If all channels passed calibration, the following screen sequence occurs.



If any of the sensors cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and lists the sensor(s) that failed to calibrate. In the example below, the oxygen and H_2S channels failed calibration. The other sensors calibrated normally.

```
FAIL SENSOR

<  >  <OXY>
<H2S>  <  >

ENTER TO CONTINUE
```

The buzzer and alarm LEDs activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and continue to the Calibration Value Screen for the PID channel. After calibrating the PID channel by following the instructions below, attempt to calibrate the standard channels again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

29. Remove the tubing from the rigid tube on the probe.
30. Unscrew the 4-gas cylinder from the regulator.
31. If you want to change the PID channel’s calibration gas value, follow Step 5 - Step 24 above beginning with the PID Calibration Gas Value Screen below instead of the standard channel Calibration Gas Value Screen.

```
CAL GAS VALUE

IBL   100 ppm


ENTER TO BEGIN CAL
```

32. With the PID Calibration Gas Value Screen displayed, press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen for the PID channel with **CAL IN PROCESS** flashing.

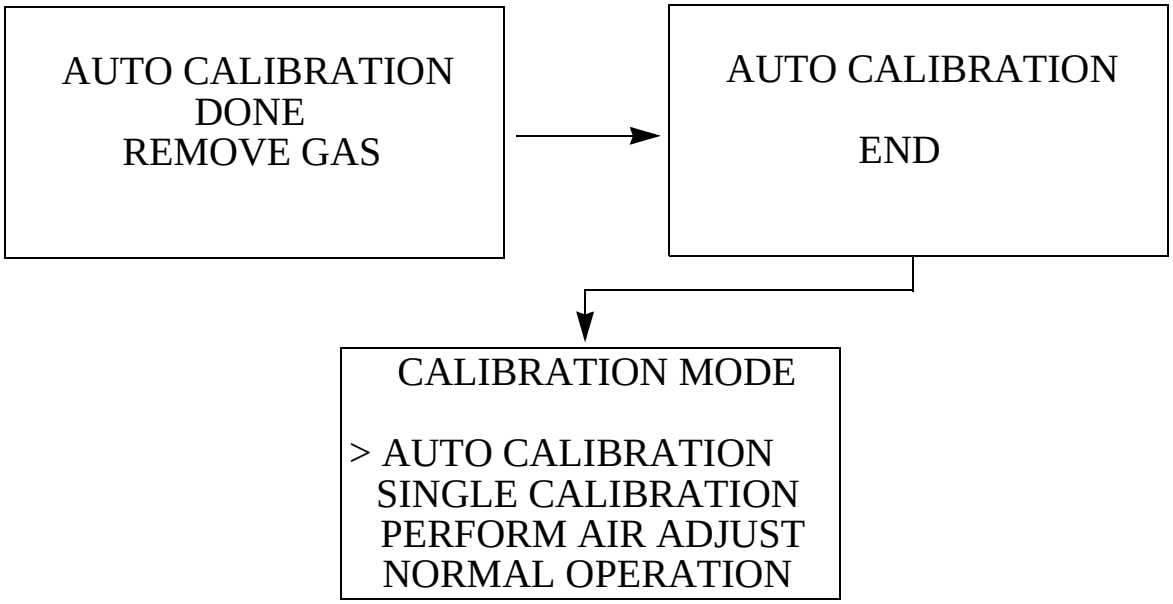
```
CAL IN PROCESS

IBL    0 ppm


ENTER WHEN DONE
```

If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the PID Cal Gas Values

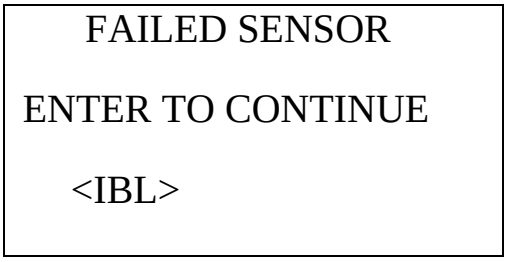
Screen.

If you do want to continue with the calibration, proceed to the next step.

33. Screw the PID calibration cylinder onto the demand flow regulator.
34. Connect the tubing from the regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for one minute.
35. Press and release the POWER ENTER RESET button to set the span adjustment for the PID channel to the programmed value.
36. If the PID channel passed calibration, the following screen sequence occurs.



If the PID channel cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and indicates that the PID sensor failed to calibrate.



The buzzer and alarm LEDs activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and continue to the Calibration Mode Screen. Attempt to calibrate the PID channel again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

37. Disconnect the tubing from the probe.
38. Unscrew the demand flow regulator from the calibration cylinder.
39. Use the RANGE ▼SHIFT button to place the cursor next to the **NORMAL OPERATION** menu option, then press and release the POWER ENTER RESET button to return to Measuring Mode.

Maintenance

The PID sensor includes user serviceable parts. They are the lamp and the electrode stack. This section includes procedures for cleaning the lamp, replacing the lamp, replacing the electrode stack, and replacing the PID sensor.

Cleaning the PID Sensor's Lamp

Clean the lamp if you notice a significant drop in sensitivity from one scheduled calibration to another or if you are not able to calibrate the PID channel. See the "PID EAGLE 2 Spare Parts" on page 164 for lamp cleaning kit ordering information. The lamp cleaning kit includes the following items:

- an electrode stack removal tool
- a small vial of aluminum oxide powder
- 40 cotton swabs
- 10 finger cots

Perform the following procedure to clean the PID lamp:

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main PCB with the cable that connects the top case to the main PCB.
5. Lay the top case down next to the bottom case to allow access to the flow system.
6. Locate the PID sensor adapter. It has a five wire cable and is normally located next to the pump. The cable has a connector that mates to a PID sub PCB that is installed on the main PCB. Figure 26 on page 134 shows a PID sensor in a typical location.

7. Grasp the sensor adapter firmly and pull it out of the PID flow chamber. Rock it back and forth gently if necessary to pull it out. Take care not to pull the cable connector from the PID sub PCB.
8. The PID sensor protrudes from one end of the sensor adapter. Grasp the PID sensor firmly and pull it out of the sensor adapter.
9. Place the PID sensor face down on a flat clean working surface.

NOTE: Do not touch the lamp window with your fingers as this may contaminate the window with finger oil. At this point it is recommended that the finger cots be used on the fingers handling the lamp. Finger cots are included with the lamp cleaning kit.

10. Hold the PID sensor steady on the working surface with one hand and using the other hand, locate the tabs on the electrode stack removal tool and insert them into the slots on the side of the PID sensor near the face.

Figure 27: Using Removal Tool

11. Squeeze the removal tool to push the tabs into the sensor slots until the electrode stack and lamp are released.
12. Carefully lift the PID sensor body away from the electrode stack and lamp. Take care not to touch the lamp window, the flat end of the lamp, with your fingers. If the lamp remains lodged in the sensor body, carefully remove it with tweezers.

Figure 28: Lamp Window Location

13. If the spring in the lamp cavity comes out, place it back into the lamp cavity.
14. Hold the lamp in one hand being careful not to touch the lamp window with your fingers.
15. With the other hand collect a small amount of aluminum oxide powder on a cotton swab.
16. Use this cotton swab to polish the PID lamp window. Use a circular motion, applying light pressure to clean the lamp window. Do not touch the lamp window with your fingers.

Figure 29: Polishing the Electrode Lamp Window

17. Continue polishing until you can hear a squeaking sound made by the cotton swab moving over the window surface. This usually occurs after about 15 seconds of polishing.
18. Remove the residual powder from the lamp window with a clean cotton swab. Take care not to touch the tip of the cotton swab that is used to clean the lamp as this may contaminate it with finger oil.

19. Ensure the lamp is completely dry and any visible signs of contamination are removed before reinstalling.
20. Hold the electrode stack between the thumb and forefinger of one hand and place the window end of the lamp inside the O-ring seal in the electrode stack with the other hand as shown below.

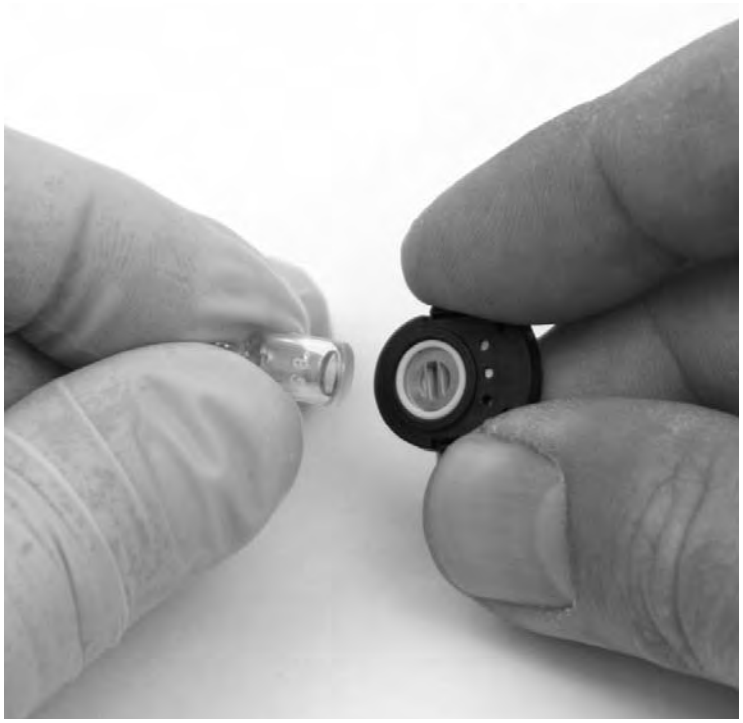


Figure 30: Reinstalling the Electrode Lamp

21. Twisting the lamp slightly during insertion will help to ensure the lamp window is snug against the stack's front electrode. The lamp should be supported by the O-ring.
22. Continuing to hold the electrode stack between your forefinger and thumb, carefully insert the lamp into the lamp cavity in the sensor ensuring that the lamp remains in position.
23. Press in the electrode stack firmly to ensure that the stack wing clips are engaged and the faces of the stack and sensor body are flush.
24. Carefully line up the PID sensor’s pins with the sockets in the bottom of the sensor adapter and gently lower the sensor into the adapter until you feel it contact the bottom.
25. Do not attempt to push the sensor in farther once it makes contact with the bottom of the adapter until you are sure that the sensor’s pins are engaged with the sockets. If you feel that the pins did not engage the sockets, slightly rotate the sensor back and forth without putting pressure on it until you feel the pins engage the sockets.
26. Push the sensor into the sockets until it bottoms out.

27. Insert the sensor adapter into the PID flow chamber and push it in until it bottoms out.
28. Confirm that the main PCB is seated in its slots and that its bottom edge is resting on the bottom of the bottom case. If the main PCB is not seated properly, it may be damaged when the top case is re-installed.
29. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
30. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.
31. Calibrate the PID channel as described in “PID Calibration” on page 139.

Replacing the PID Sensor’s Lamp

If cleaning the PID lamp does not resolve any calibration problems you may be having, the lamp may need to be replaced. Perform the following procedure to replace the PID lamp:

NOTE: Do not touch the new lamp window (the flat end) with your fingers as this may contaminate the window with finger oil.

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main PCB with the cable that connects the top case to the main PCB.
5. Lay the top case down next to the bottom case to allow access to the flow system.
6. Locate the PID sensor adapter. It has a five wire cable and is normally located next to the pump. The cable has a connector that mates to a PID sub PCB that is installed on the main PCB. Figure 26 on page 134 shows a PID sensor in a typical location.
7. Grasp the sensor adapter firmly and pull it out of the PID flow chamber. Rock it back and forth gently if necessary to pull it out. Take care not to pull the cable connector from the PID sub PCB.
8. The PID sensor protrudes from one end of the sensor adapter. Grasp the PID sensor firmly and pull it out of the sensor adapter.

9. Place the PID sensor face down on a flat clean working surface.
10. Hold the PID sensor steady on the working surface with one hand and using the other hand, locate the tabs on the electrode stack removal tool and insert them into the slots on the side of the PID sensor near the face.

Figure 31: Using Removal Tool

11. Squeeze the removal tool to push the tabs into the sensor slots until the electrode stack and lamp are released.
12. Carefully lift the PID sensor body away from the electrode stack and lamp. If the lamp remains lodged in the sensor body, carefully remove it with tweezers.
13. If the spring in the lamp cavity comes out, place it back into the lamp cavity.
14. Discard the old PID lamp.

NOTE: At this point it is recommended that the finger cots be used on the fingers handling the lamp. Finger cots are included with the lamp cleaning kit.

15. Hold the electrode stack between the thumb and forefinger of one hand and place the window end of the new lamp inside the O-ring seal in the electrode stack with the other hand as shown below. Take care not to touch the lamp window.

Figure 32: Reinstalling the Electrode Lamp

16. Twisting the lamp slightly during insertion will help to ensure the lamp window is snug against the stack's front electrode. The lamp should be supported by the O-ring.
17. Continuing to hold the electrode stack between your forefinger and thumb, carefully insert the lamp into the lamp cavity in the sensor ensuring that the lamp remains in position.
18. Press in the electrode stack firmly to ensure that the stack wing clips are engaged and the faces of the stack and sensor body are flush.
19. Carefully line up the PID sensor’s pins with the sockets in the bottom of the sensor adapter and gently lower the sensor into the adapter until you feel it contact the bottom.
20. Do not attempt to push the sensor in farther once it makes contact with the bottom of the adapter until you are sure that the sensor’s pins are engaged with the sockets. If you feel that the pins did not engage the sockets, slightly rotate the sensor back and forth without putting pressure on it until you feel the pins engage the sockets.
21. Push the sensor into the sockets until it bottoms out.
22. Insert the sensor adapter into the PID flow chamber and push it in until it bottoms out.
23. Confirm that the main PCB is seated in its slots and that its bottom edge is resting on the bottom of the bottom case. If the main PCB is not seated properly, it may be damaged when the top case is re-installed.

24. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
25. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.
26. Calibrate the PID channel as described in “PID Calibration” on page 139.

Replacing the Electrode Stack

The electrode stack can last for the life of the PID sensor if the EAGLE 2 is used in a very clean, controlled environment. When used in a heavily contaminated or dirty environment, the electrode stack may only last a month. A contaminated electrode stack will cause a drop in sensitivity which can cause problems calibrating the PID channel. The electrode stack should be replaced if the PID sensor shows signs of contamination even after cleaning or replacing the lamp.

NOTE: Do not touch the new lamp window (the flat end) with your fingers as this may contaminate the window with finger oil.

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main PCB with the cable that connects the top case to the main PCB.
5. Lay the top case down next to the bottom case to allow access to the flow system.
6. Locate the PID sensor adapter. It has a five wire cable and is normally located next to the pump. The cable has a connector that mates to a PID sub PCB that is installed on the main PCB. Figure 26 on page 134 shows a PID sensor in a typical location.
7. Grasp the sensor adapter firmly and pull it out of the PID flow chamber. Rock it back and forth gently if necessary to pull it out. Take care not to pull the cable connector from the PID sub PCB.
8. The PID sensor protrudes from one end of the sensor adapter. Grasp the PID sensor firmly and pull it out of the sensor adapter.
9. Place the PID sensor face down on a flat clean working surface.

NOTE: At this point it is recommended that the finger cots be used on the fingers handling the lamp. Finger cots are included with the lamp cleaning kit.

10. Hold the PID sensor steady on the working surface with one hand and using the other hand, locate the tabs on the electrode stack removal tool and insert them into the slots on the side of the PID sensor near the face.

Figure 33: Using Removal Tool

11. Squeeze the removal tool to push the tabs into the sensor slots until the electrode stack and lamp are released.
12. Carefully lift the PID sensor body away from the electrode stack and lamp. If the lamp remains lodged in the sensor body, carefully remove it with tweezers.
13. If the spring in the lamp cavity comes out, place it back into the lamp cavity.
14. Discard the old electrode stack.
15. Hold the new electrode stack between the thumb and forefinger of one hand and place the window end of the lamp inside the O-ring seal in the new electrode stack with the other hand as shown below. Take care not to touch the lamp window.

Figure 34: Reinstalling Electrode Lamp

16. Twisting the lamp slightly during insertion will help to ensure the lamp window is snug against the stack's front electrode. The lamp should be supported by the O-ring.
17. Continuing to hold the electrode stack between your forefinger and thumb, carefully insert the lamp into the lamp cavity in the sensor ensuring that the lamp remains in position.
18. Press in the electrode stack firmly to ensure that the stack wing clips are engaged and the faces of the stack and sensor body are flush.
19. Carefully line up the PID sensor’s pins with the sockets in the bottom of the sensor adapter and gently lower the sensor into the adapter until you feel it contact the bottom.
20. Do not attempt to push the sensor in farther once it makes contact with the bottom of the adapter until you are sure that the sensor’s pins are engaged with the sockets. If you feel that the pins did not engage the sockets, slightly rotate the sensor back and forth without putting pressure on it until you feel the pins engage the sockets.
21. Push the sensor into the sockets until it bottoms out.
22. Insert the sensor adapter into the PID flow chamber and push it in until it bottoms out.
23. Confirm that the main PCB is seated in its slots and that its bottom edge

is resting on the bottom of the bottom case. If the main PCB is not seated properly, it may be damaged when the top case is re-installed.

24. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
25. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.
26. Calibrate the PID channel as described in “PID Calibration” on page 139.

Replacing the PID Sensor

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main PCB with the cable that connects the top case to the main PCB.
5. Lay the top case down next to the bottom case to allow access to the flow system.
6. Locate the PID sensor adapter. It has a five wire cable and is normally located next to the pump. The cable has a connector that mates to a PID sub PCB that is installed on the main PCB. Figure 26 on page 134 shows a PID sensor in a typical location.
7. Grasp the sensor adapter firmly and pull it out of the PID flow chamber. Rock it back and forth gently if necessary to pull it out.Take care not to pull the cable connector from the PID sub PCB.
8. The PID sensor protrudes from one end of the sensor adapter. Grasp the old PID sensor firmly and pull it out of the sensor adapter.
9. Carefully line up the new PID sensor’s pins with the sockets in the bottom of the sensor adapter and gently lower the sensor into the adapter until you feel it contact the bottom.
10. Do not attempt to push the sensor in farther once it makes contact with the bottom of the adapter until you are sure that the sensor’s pins are engaged with the sockets. If you feel that the pins did not engage the sockets, slightly rotate the sensor back and forth without putting pressure on it until you feel the pins engage the sockets.
11. Push the sensor into the sockets until it bottoms out.

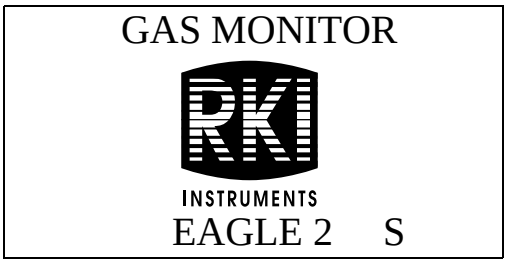
12. Insert the sensor adapter into the PID flow chamber and push it in until it bottoms out.
13. Plug the PID cable connector into the PID sub PCB on the main PCB.
14. Confirm that the main PCB is seated in its slots and that its bottom edge is resting on the bottom of the bottom case. If the main PCB is not seated properly, it may be damaged when the top case is re-installed.
15. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
16. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.
17. Calibrate the PID channel as described in "PID Calibration" on page 139.

Configuring the PID Gas in Setup Mode

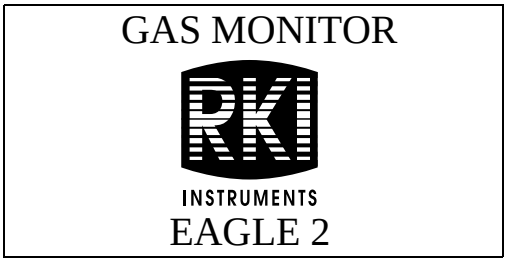
The standard PID channel is configured for and calibrated to isobutylene. If calibration to a different gas is required for an application, the PID channel can also be configured for other gases in the CONFIGURE GASES menu item in Setup Mode. To change the gas configuration of the PID channel in Setup Mode, do the following:

WARNING: The EAGLE 2 is not in operation as a gas detector while in Setup Mode.

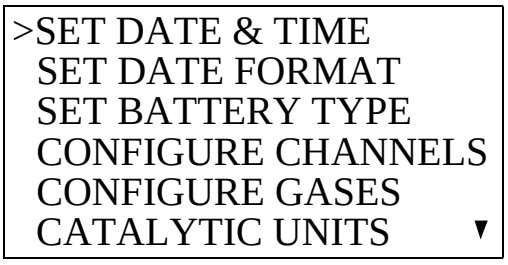
1. Take the EAGLE 2 to a non-hazardous location and turn it off if it is on.
2. Press and hold AIR ▲ YES and RANGE ▼ SHIFT, then press and hold POWER ENTER RESET. When you hear a beep, release the buttons.
3. The LCD will show the following screen for a few seconds with the "S" in the lower right corner indicating the unit is entering Setup Mode.



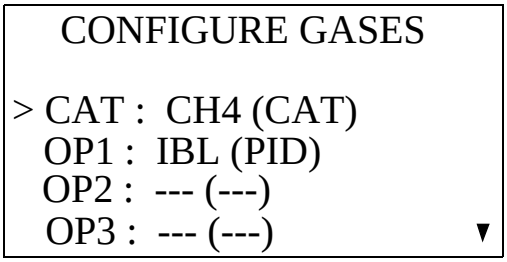
4. The “S” will then disappear and the following screen will appear for a few seconds.



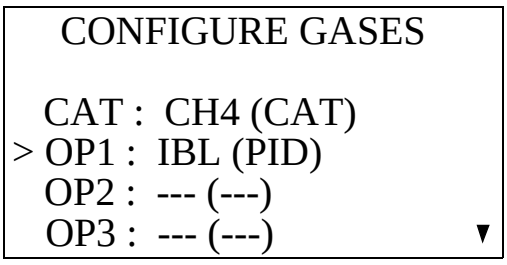
5. If the unit prompts you for the password, enter it by using AIR ▲ YES and RANGE ▼SHIFT to select each password number and then pressing and releasing the POWER ENTER RESET button to enter it and move on to the next number until all of the numbers are entered. The main menu displays. It displays six menu items at a time.



6. Use the RANGE ▼SHIFT button to move the cursor down the menu to CONFIGURE GASES.
7. Press and release POWER ENTER RESET. The Configure Gases Screen appears with the cursor flashing next to CAT, the catalytic sensor. If an EAGLE 2 has a PID sensor installed, one of the three optional sensor types, OP1, OP2, or OP3 will indicate it is a PID. In the example below, OP1 is shown as a PID sensor.

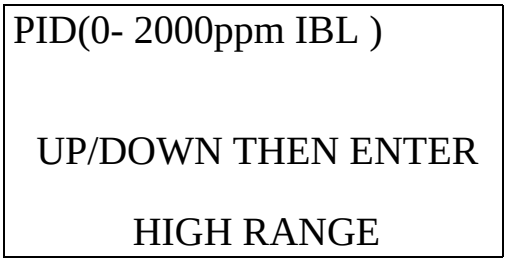


8. Use RANGE ▼ SHIFT to move the cursor down the menu to the PID sensor.



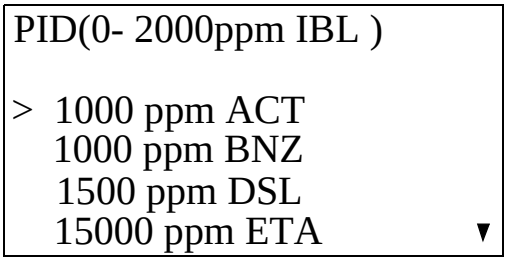
9. To change the PID sensor gas configuration, press and release POWER ENTER RESET.

10. A screen appears that indicates the PID type, low range or high range (flashing), and the detection range for the currently configured gas. In the example below, the PID sensor is currently configured as a high range sensor for 0 - 2,000 ppm isobutylene.



11. Use AIR ▲ YES and RANGE ▼ SHIFT to set the correct range, low or high, for the sensor that is installed.

    Press and release POWER ENTER RESET. A screen appears with gas configuration choices for the PID sensor. The screen below illustrates the first four choices for a high range PID.

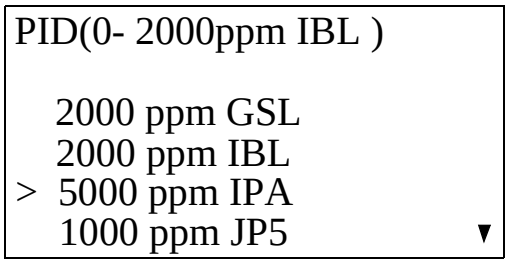


    There are 17 choices that can be viewed on five screens. Table 16 below lists all of the gas configuration choices.

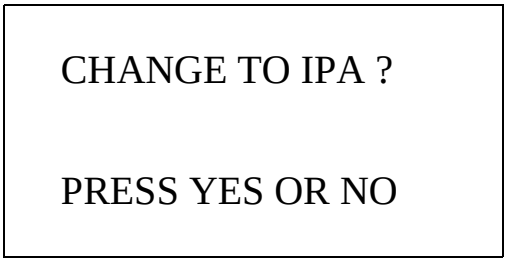
Table 16: PID Gas Configurations

Gas Name (LCD Abbreviation)	Detection Range Full Scale Low Range/High Range
Acetone (ACT)	30.00 ppm/1000 ppm
Benzene (BNZ	25.00 ppm/1000 ppm
Diesel Fuel No. 1 (DSL)	40.00 ppm/1500 ppm
Ethanol (ETA)	400.0 ppm/15000 ppm
Gasoline (GSL)	50.00 ppm/2000 ppm
Isobutylene (IBL) Standard Factory Gas Configuration	50.00 ppm/2000 ppm
Isopropanol (IPA)	200.0 ppm/5000 ppm
JP-5 Fuel (JP5)	30.00 ppm/1000 ppm
Methyl Ethyl Ketone (MEK)	40.00 ppm/1500 ppm
Toluene (TOL)	25.00 ppm/1000 ppm
N-Hexane (HEX)	200.0 ppm/5000 ppm
Propylene (PRL)	50.00 ppm/2500 ppm
Styrene (STY)	20.00 ppm/500 ppm
Tetrachloroethylene (PCE)	30.00 ppm/1000 ppm
Trichloroethylene (TCE)	30.00 ppm/1000 ppm
Vinyl Chloride (VCM)	100.0 ppm/4000 ppm
PID (PID) User Defined Gas Loaded with Maintenance Program	50.0 ppm/2000 ppm

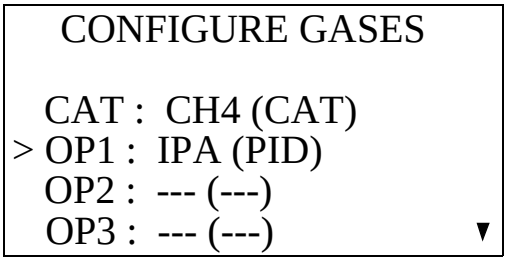
12. Use AIR ▲ YES and RANGE ▼ SHIFT to place the cursor next to the desired gas. In the example below, the cursor is placed next to isopropanol (IPA).



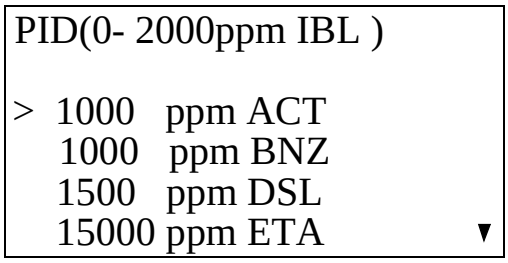
13. Press and release the POWER ENTER RESET button. The LCD will ask for confirmation that you want to change the configured gas.



14. To change the gas configuration, press and release AIR ▲ YES. The unit will return to the Configure Gases Screen reflecting the new gas configuration.



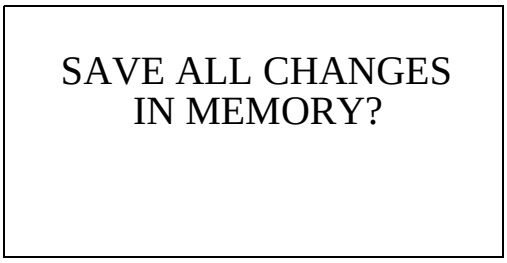
If you do not want to change the gas configuration, press and release DISPLAY ADJUST NO. The unit will return to the first gas configuration choice screen with the gas configuration unchanged.



Select a different gas and go to Step 13 or press and release DISPLAY ADJUST NO to return to the Gas Configuration screen.

15. Use RANGE ▼ SHIFT to place the cursor next to **END**.
16. Press and release POWER ENTER RESET to return to the main menu.
17. Use RANGE ▼ SHIFT to place the cursor in front of **NORMAL OPERATION** at the bottom of the main menu.
18. Press and release POWER ENTER RESET.

19. A screen appears that asks if you want to save the changes you have made.



NOTE: If you entered Setup Mode and did not make any changes, the above screen will still appear. In this case, press and release DISPLAY ADJUST NO to proceed to exit Setup Mode and begin the EAGLE 2's startup sequence.

20. If you do not want to save the changes, press and release DISPLAY ADJUST NO. The unit will begin its startup sequence without saving the changes.

    If you do want to save the changes, press and release AIR ▲ YES and continue with the next step.

21. A confirmation screen appears asking if you are sure you want to save the changes.

22. If you want to save the changes, press and release AIR ▲ YES to save the changes. A screen will appear for a few seconds indicating that the changes have been saved and the unit will begin its startup sequence.

    If you do not want to save the changes, press and release DISPLAY ADJUST NO to proceed to the unit's startup sequence without saving changes.

Parts List

Table 17: PID EAGLE 2 Spare Parts

Part Number	Description
33-0560RK	Electrode stack, 0 - 50 ppm, 2 pack
33-0561RK	Electrode stack, 0 - 2,000 ppm, 2 pack
51-1500RK	Replacement lamp, 0 - 50 ppm
51-1501RK	Replacement lamp, 0 - 2,000 ppm
57-2005RK	Adapter assembly, for PID sensor
61-0300RK-01	PID sensor, 0 - 50 ppm VOC
61-0300RK-02	PID sensor, 0 - 2,000 ppm VOC
80-0605RK	Teflon lined sample hose, 5 feet
80-0610RK	Teflon lined sample hose, 10 feet
80-0615RK	Teflon lined sample hose, 15 feet
80-0620RK	Teflon lined sample hose, 20 feet
81-0103RK-01	Calibration cylinder, isobutylene, 100 ppm in air, 34 liter steel
81-0103RK-03	Calibration cylinder, isobutylene, 100 ppm in air, 103 liter steel
81-0103RK-04	Calibration cylinder, isobutylene, 100 ppm in air, 34 liter aluminum
81-0104RK-01	Calibration cylinder, isobutylene, 10 ppm in air, 34 liter steel
81-0104RK-03	Calibration cylinder, isobutylene, 10 ppm in air, 103 liter steel
81-0104RK-04	Calibration cylinder, isobutylene, 10 ppm in air, 34 liter aluminum
81-1054RK	Regulator, demand-flow type (for 58- and 103-liter aluminum or steel, and 34-liter aluminum cylinder)
81-1055RK	Regulator, demand-flow type (for 17- and 34-liter steel cylinder)
82-0003RK	Electrode stack removal tool
82-0300RK	Lamp cleaning kit with electrode stack removal tool

Appendix E: ESM-01 Toxic Sensors

Overview

The ESM-01 sensors are used to monitor levels of a variety of toxic gases. This appendix describes the EAGLE 2's ESM-01 sensors and includes instructions to use an EAGLE 2 that has one or more ESM-01 sensors installed. It also includes instructions to replace an ESM-01 sensor.

Table 18: ESM-01 Sensor Specifications

Target Gas	Detection Range (ppm)	Reading Increment	Alarm 1 Factory Setting	Alarm 2 Factory Setting	STEL (ppm)	TWA (ppm)
Ammonia (NH_3)	0 - 75.0	0.5 ppm	12.0 ppm	25.0 ppm	35	25
Arsine (AsH_3)	0 - 1.50	0.01 ppm	0.20 ppm	0.50 ppm	OFF	OFF
Chlorine (Cl_2)	0-3.00	0.02 ppm	0.50 ppm	1.50 ppm	1.00	0.50
Hydrogen Cyanide (HCN)	0 - 15.0	0.1 ppm	3.00 ppm	5.00 ppm	4.7	OFF
Phosphine (PH_3)	0 - 1.00	0.01 ppm	0.10 ppm	0.30 ppm	1.00	0.30
Sulphur Dioxide (SO_2)	0 - 6.00	0.05 ppm	1.00 ppm	2.00 ppm	1.00	0.50

Description

Table 18 above lists the available ESM-01 sensors. The ESM-01 is a smart sensor that stores sensor parameters including the target gas, detection range, alarm points, and calibration settings in its memory. So a sensor can be calibrated at the factory and shipped as a replacement sensor without the need to calibrate the sensor when it is installed as long as it is installed during the sensor's valid calibration period which is typically 3 months. In addition, you can change an existing ESM-01 channel from one type of ESM-01 sensor to another and the EAGLE 2 will automatically load all the sensor parameters

and configure the ESM-01 channel for the new sensor without the need to enter CONFIGURE CHANNELS or CONFIGURE GASES in Setup Mode. See “Replacing the ESM-01 Sensor or Changing Sensor Type” on page 177 for instructions to replace or change an ESM-01 sensor.

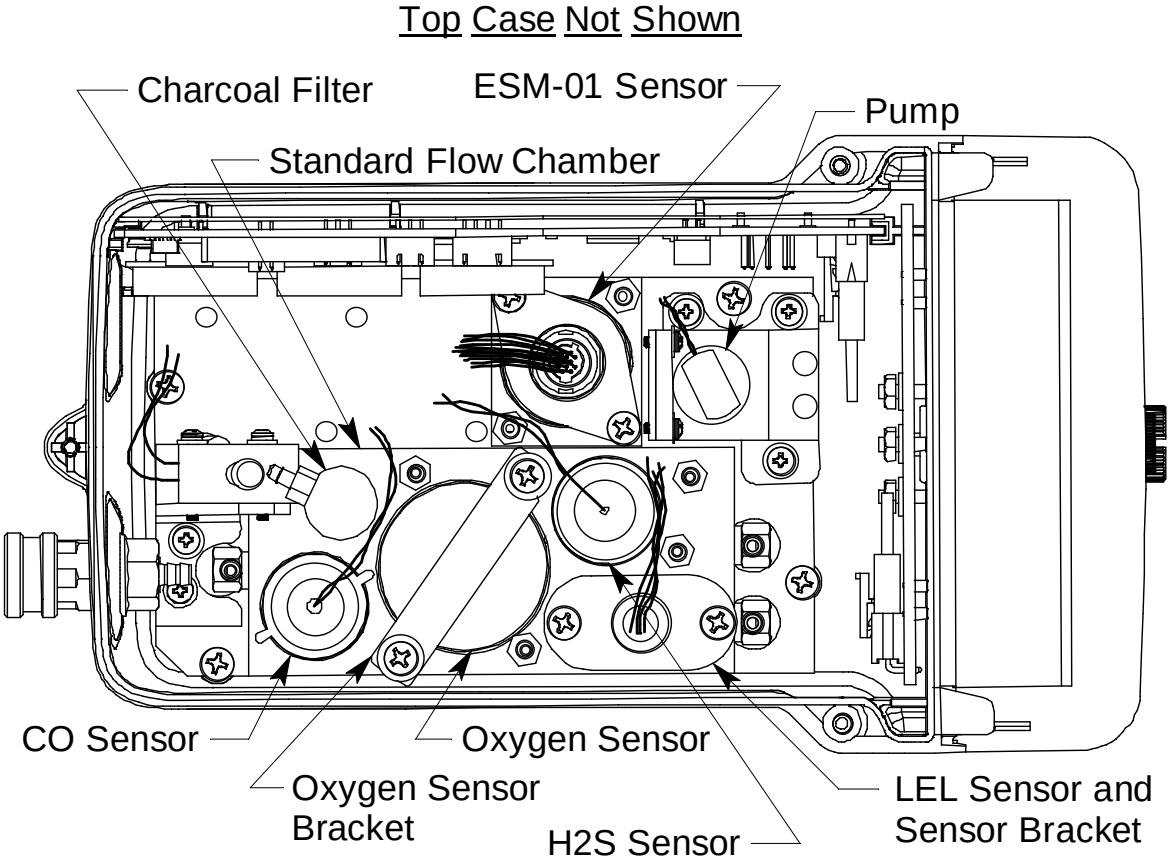


Figure 35: Typical ESM-01 Sensor Location

The ESM-01 sensor is installed in a single sensor flow chamber which is located in the area next to the standard 4-sensor flow chamber. This area can accommodate up to three single sensor flow chambers. Although the EAGLE 2 can support up to three ESM-01 sensors, many combinations are impractical for various reasons including sensor cross sensitivity to other gases. Consult RKI Instruments, Inc. for practical combinations. Figure 35 above illustrates a typical ESM-01 sensor location in front of the pump. The ESM-01 flow chamber may also be installed in one of the other two sensor chamber locations depending on the particular version of the EAGLE 2. Some ESM-01 instrument configurations do not include the 4-sensor flow chamber.

ESM-01 Sensor

The ESM-01 sensor is a cylindrical sensor with a diffusion opening on the front and a 12 pin circular connector on the back. A 12 wire cable plugs into the back of the ESM-01 sensor with a circular connector that

includes a locking lever. The other end of the cable plugs into an ESM-01 sub PCB (see description below) that is installed on the main PCB. The sensor is held in the ESM-01 flow chamber by a bracket on standoffs.

ESM-01 Sub PCB

The ESM-01 sub PCB is a circuit board that is installed on the main PCB in one of the 3 sub PCB positions when an ESM-01 sensor is used with the EAGLE 2. The ESM-01 sensor connects to the sub PCB with a 12-position connector. The sub PCB plugs into the main PCB and is held in place with a screw / flat washer / lock washer. There are no user serviceable parts on the ESM-01 sub PCB.

Start Up and Normal Operation

For instructions to startup and use an EAGLE 2 that includes an ESM-01 sensor, reference "Start Up" on page 22, "Measuring Mode, Normal Operation" on page 29, and "Measuring Mode, Alarms" on page 34. Follow these instructions keeping the following special considerations in mind:

- Several of the gases that can be monitored with an ESM-01 are absorbed in the longer EAGLE 2 sample hoses. Do not use sample hoses that are longer than the standard 5 foot hose without consulting RKI Instruments, Inc.
- If your EAGLE 2 has more than one ESM-01 sensor installed, it is possible that both sensors will respond to some of the same gases at varying levels. Make sure you understand any issues like this that may exist in your particular instrument.
- The SO_2 and HCN ESM-01 sensors include a replaceable H_2S scrubber disk inside the sensor face. The SO_2 and HCN sensors respond to H_2S, so the H_2S scrubber disk removes H_2S from the sample to avoid false SO_2 and HCN readings. See "Replacing the H_2S Scrubber in the SO_2 and HCN Sensors" on page 178 for instructions to replace the H_2S scrubber.

ESM-01 Calibration

An ESM-01 channel can be calibrated using the auto calibration method or the single calibration method. To calibrate an ESM-01 channel using the single calibration method, see "Calibrating Using the Single Calibration Method" on page 63 and follow the instructions

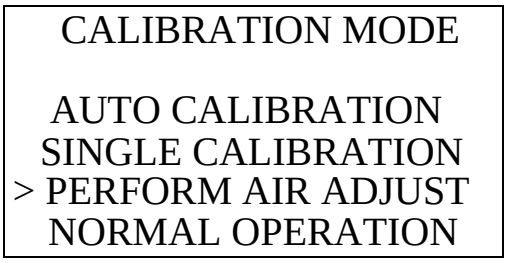
for calibrating a single channel. If your instrument is a multi-channel instrument that includes one or more ESM-01 channels, RKI Instruments, Inc. recommends using the auto calibration method for convenience. The calibration instructions below show a 5 channel instrument which has the four standard channels, LEL / oxygen / H_2S / CO, and an ESM-01 channel for ammonia (NH_3). To use the auto calibration method to calibrate a multi-channel instrument that includes an ESM-01 channel, do the following:

NOTE: If your instrument has more than one ESM-01 sensor, you will need a calibration cylinder for each sensor.

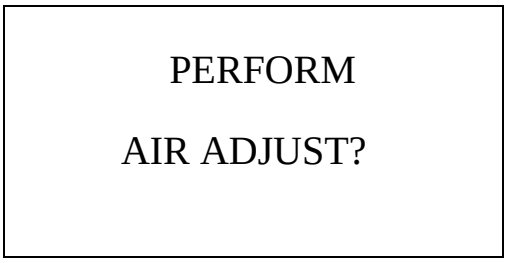
1. See "Calibration Supplies and Equipment" on page 56 for a description of the necessary calibration supplies. In addition to an appropriate multi-gas cylinder that is used to calibrate any active standard channels, you will also need a cylinder to calibrate the ESM-01 channel. See Table 19 on page 180 for available cylinders. Make sure your calibration cylinder is appropriate for the ESM-01 detection range.
2. Find a fresh-air environment. This is an environment free of toxic or combustible gases and of normal oxygen content (20.9%).
3. While in Measuring Mode, press and hold the RANGE ▼SHIFT button, then press the DISPLAY ADJUST NO button and release both buttons.
4. If the unit prompts you for the password, enter it by using the AIR ▲ YES and RANGE ▼SHIFT buttons to select each password number and then pressing and releasing POWER ENTER RESET to enter the number and move on to the next one.
5. The Calibration Mode Screen displays with the cursor next to **AUTO CALIBRATION**.

```
CALIBRATION MODE

> AUTO CALIBRATION
  SINGLE CALIBRATION
  PERFORM AIR ADJUST
  NORMAL OPERATION
```

6. Move the cursor to the **PERFORM AIR ADJUST** menu item by using the RANGE ▼ SHIFT button.

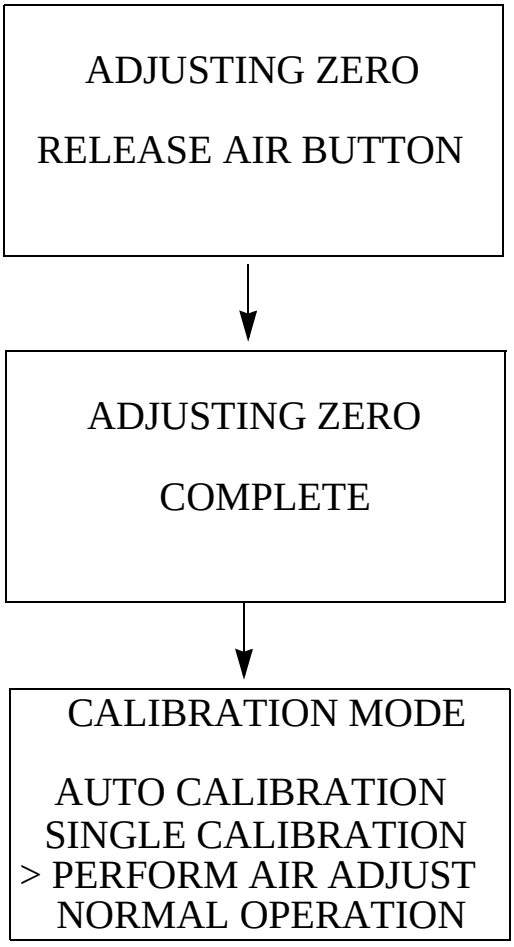


7. Press and release the POWER ENTER RESET button. The following screen appears.



8. Press and release the AIR ▲ YES button to continue.
   If you do not want to continue, press the DISPLAY ADJUST NO button and the unit will return to the Calibration Mode Screen.

9. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.



10. Install the demand flow regulator onto the multi-gas calibration cylinder.
11. Connect the sample tubing to the demand flow regulator.
12. Install the probe on the EAGLE 2 inlet fitting. Make sure the probe is complete with internal O-ring and membrane and that the two halves of the probe are tightened firmly together to avoid leaks that can affect the calibration. See Figure 20 on page 73 for an illustration of the internal parts of the probe.

13. Move the cursor next to the **AUTO CALIBRATION** menu item by using the AIR ▲ YES button.

```
CALIBRATION MODE

> AUTO CALIBRATION
  SINGLE CALIBRATION
  PERFORM AIR ADJUST
  NORMAL OPERATION
```

14. Press and release the POWER ENTER RESET button to display the Calibration Gas Values Screen.

```
CAL GAS VALUES
CH4     50  %LEL
OXY   12.0  vol%
H2S   25.0  ppm
CO      50  ppm
ENTER TO BEGIN CAL
```

The gas concentrations displayed in the Calibration Gas Values Screen must match the gas concentrations listed on the 4-gas calibration cylinder.
If *all* concentrations match, go to Step 25.
If *one or more* concentrations *do not* match, continue with Step 15.
If you do not want to continue with the calibration, press and release the DISPLAY ADJUST NO button to return to the Calibration Mode Screen.

NOTE: The RKI 4-gas cylinder typically contains 12% O_2 by volume. When using the auto calibration method, be sure to set the "OXY" auto calibration value to agree with the concentration listed on the cylinder's label, not zero.

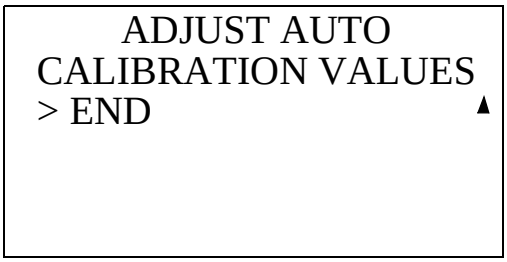
15. To adjust the values on the screen, press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both. The following screen appears with the cursor next to **CH4**.

```
ADJUST AUTO
CALIBRATION VALUES
> CH4     50   %LEL
  OXY   12.0   vol%
  H2S   25.0   ppm
  CO      50   ppm      ▼
```

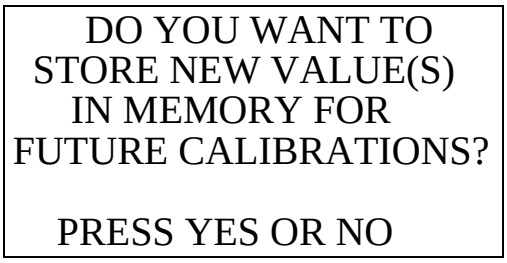
16. Place the cursor next to the channel whose gas value you want to change using the AIR ▲ YES and RANGE ▼ SHIFT buttons.
17. Press and release the POWER ENTER RESET button to select the

channel. The calibration gas value begins to flash.

18. Use the AIR ▲ YES and RANGE ▼ SHIFT buttons to adjust the calibration gas setting to the desired value.
19. Press and release the POWER ENTER RESET button to save the change. The calibration gas value stops flashing.
20. Repeat Step 16 through Step 19 for any other channels that need to be changed.
21. When you are done adjusting the calibration gas values, move the cursor down past the bottom of the screen next to **END**.



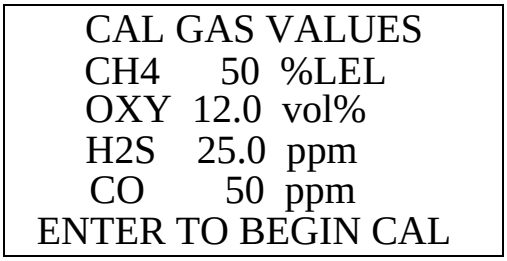
22. Press and release the POWER ENTER RESET button. The following screen appears.



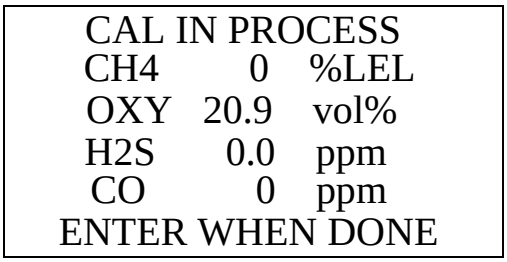
23. If you select YES by pressing and releasing the AIR ▲ YES button, the changes that you made will be saved in the EAGLE 2's memory as the new auto calibration gas values.

    If you select NO by pressing and releasing the DISPLAY ADJUST NO button, the changes you made will be used for any calibrations performed during the current operating session only. The EAGLE 2 will delete the changes when the unit is turned off and will load the previous set of auto calibration values when it is turned on again.

24. When you make your selection and press the desired button, the unit returns to the Calibration Gas Values Screen.



25. Press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen with **CAL IN PROCESS** flashing.

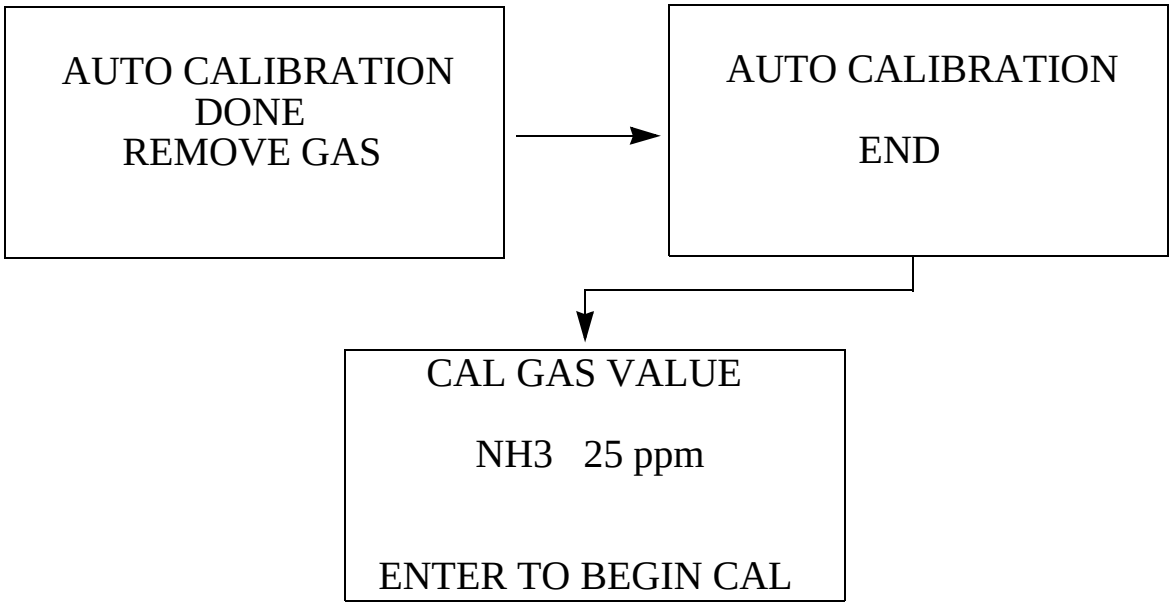


If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the Cal Gas Values Screen.

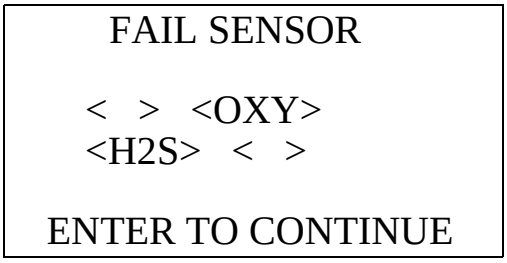
If you do want to continue with the calibration, proceed to the next step.

26. Connect the tubing from the demand flow regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for one minute.
27. Press and release the POWER ENTER RESET button to set the span adjustment for each channel to the programmed values.

28. If all channels passed calibration, the following screen sequence occurs.



If any of the sensors cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and lists the sensor(s) that failed to calibrate. In the example below, the oxygen and H_2S channels failed calibration. The other sensors calibrated normally.

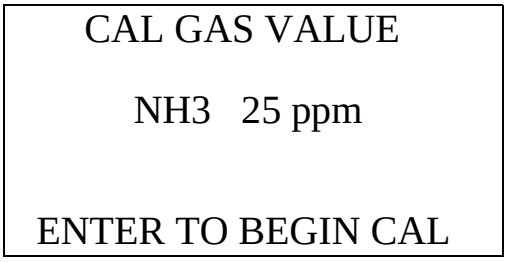


The buzzer and alarm LEDs activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and continue to the Calibration Value Screen for the ESM-01 channel. After calibrating the ESM-01 channel by following the instructions below, attempt to calibrate the standard channels again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

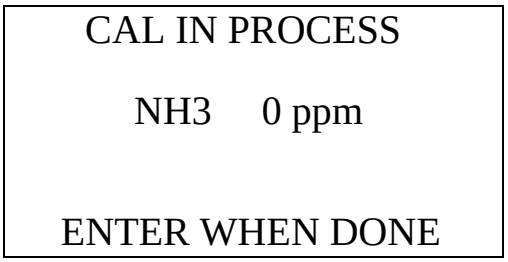
29. Remove the tubing from the rigid tube on the probe.

30. Unscrew the 4-gas cylinder from the demand flow regulator.

31. If you want to change the ESM-01 channel's calibration gas value, follow Step 15 - Step 24 above beginning with the ESM-01 Calibration Gas Value Screen below instead of the standard channel Calibration Gas Value Screen.



32. With the ESM-01 Calibration Gas Value Screen displayed, press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen for the ESM-01 channel with **CAL IN PROCESS** flashing.

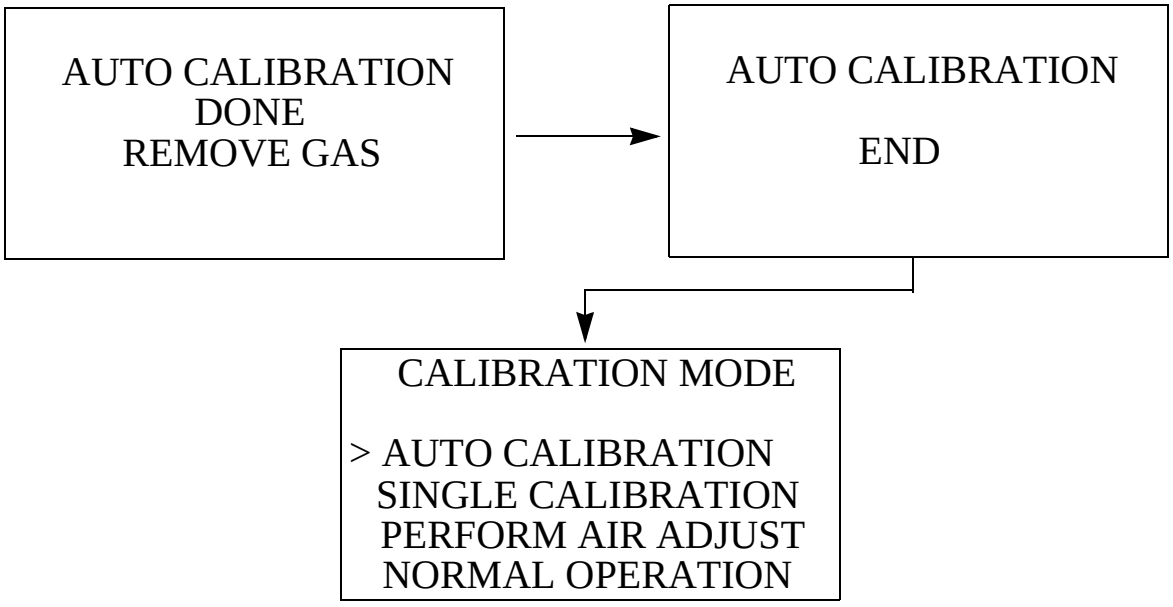


If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the ESM-01 Cal Gas Values Screen.

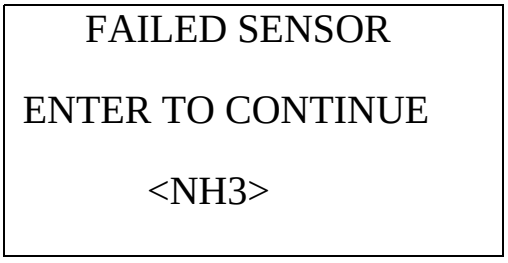
If you do want to continue with the calibration, proceed to the next step.

33. Screw the ESM-01 calibration cylinder onto the demand flow regulator.
34. Connect the tubing from the regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for two minutes. If you notice that the gas reading stabilizes sooner, you can reduce the gas application time to the time it takes the gas reading to stabilize.
35. Press and release the POWER ENTER RESET button to set the span adjustment for the ESM-01 channel to the programmed value.

36. If the ESM-01 channel passed calibration, the following screen sequence occurs.



If the ESM-01 channel cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and indicates that the ESM-01 sensor failed to calibrate.



The buzzer and alarm LEDs activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and continue to the Calibration Mode Screen. Attempt to calibrate the ESM-01 channel again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

37. Disconnect the tubing from the probe.
38. Unscrew the demand flow regulator from the calibration cylinder.
39. Use the RANGE ▼SHIFT button to place the cursor next to the **NORMAL OPERATIO**N menu option, then press and release the POWER ENTER RESET button to return to Measuring Mode.

Maintenance

The SO_2 and HCN ESM-01 sensors are the only ESM-01 sensors that include user serviceable parts. This section includes a procedure for replacing an ESM-01 sensor and for replacing the H_2S scrubber in the SO_2 and HCN sensors. When replacing a sensor, you may either replace it with another of the same sensor or you may install a different ESM-01 sensor. If a different one is installed, the EAGLE 2 will load the sensor parameters and configure the ESM-01 channel for the new sensor.

Replacing the ESM-01 Sensor or Changing Sensor Type

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main PCB with the cable that connects the top case to the main PCB.
5. Lay the top case down next to the bottom case to allow access to the flow system.
6. Locate the ESM-01 sensor. It has a twelve wire cable with a connector that mates to an ESM-01 sub PCB that is installed on the main PCB and is normally located next to the pump. Figure 35 on page 166 shows an ESM-01 sensor in a typical location.
7. Unscrew and remove the two screws that hold down the ESM-01 sensor bracket.
8. Grasp the sensor firmly and pull it out of the ESM-01 flow chamber. Rock it back and forth gently if necessary to pull it out. Take care not to pull the cable from the sub PCB.
9. Rotate the locking lever counterclockwise on the cable connector that mates to the ESM-01 sensor to unlock it.
10. Unplug the old ESM-01 sensor from the cable.
11. Connect the new ESM-01 sensor to the sensor cable and rotate the locking lever clockwise to lock the connector.
12. Insert the sensor into the ESM-01 flow chamber and push it in until it bottoms out.

13. Line up the holes in the ESM-01 sensor bracket with the two standoffs on the ESM-01 chamber.
14. Install the two sensor bracket screws.
15. Confirm that the main PCB is seated in its slots and that its bottom edge is resting on the bottom of the bottom case. If the main PCB is not seated properly, it may be damaged when the top case is re-installed.
16. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
17. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.
18. Calibrate the ESM-01 channel as described in “ESM-01 Calibration” on page 167.

Replacing the H_2S Scrubber in the SO_2 and HCN Sensors

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main PCB with the cable that connects the top case to the main PCB.
5. Lay the top case down next to the bottom case to allow access to the flow system.
6. Locate the ESM-01 sensor. It has a twelve wire cable with a connector that mates to an ESM-01 sub PCB that is installed on the main PCB and is normally located next to the pump. Figure 35 on page 166 shows an ESM-01 sensor in a typical location.
7. Unscrew and remove the two screws that hold down the ESM-01 sensor bracket.
8. Grasp the sensor firmly and pull it out of the ESM-01 flow chamber. Rock it back and forth gently if necessary to pull it out. Take care not to pull the cable from the sub PCB.
9. Rotate the locking lever counterclockwise on the cable connector that mates to the ESM-01 sensor to unlock it.
10. Unplug the ESM-01 sensor from the cable.

11. The ESM-01 sensor consists of an electrolyte reservoir assembly retained in the sensor body by a threaded collar on the connector end of the sensor. Unscrew the collar from the sensor body.

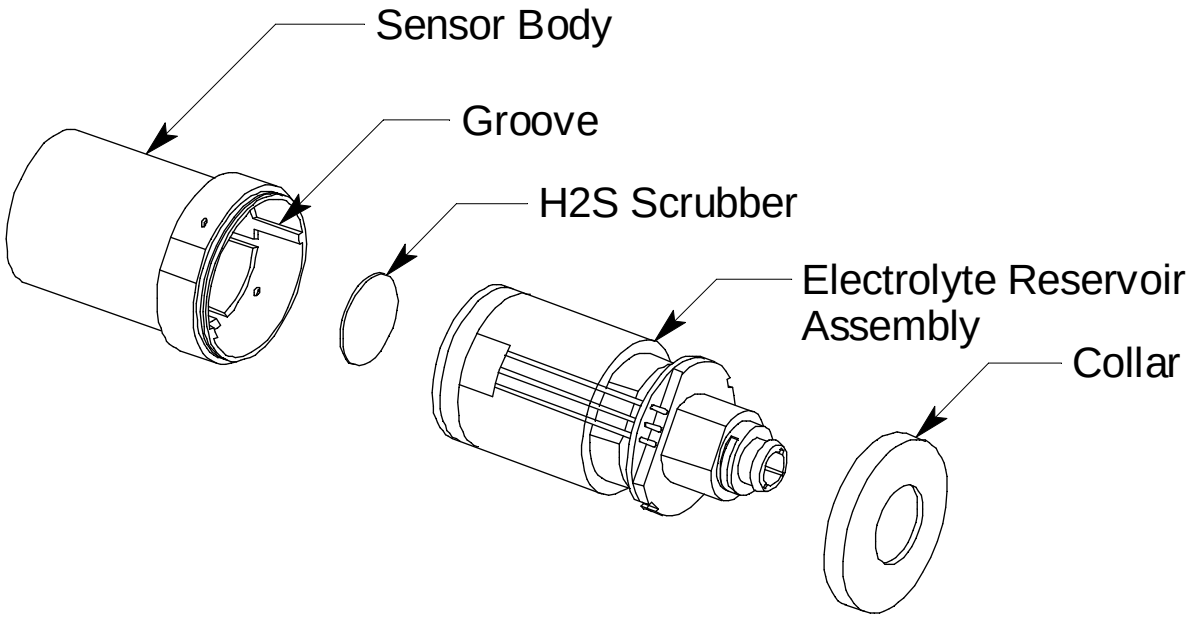


Figure 36: ESM-01 Sensor Component Location

12. Grasp the connector and lift the electrolyte reservoir assembly out of the sensor body.
13. Turn the body upside down to remove the H_2S scrubber. If it does not come out, push on it from the top of the upside down body.
14. Discard the old H_2S scrubber.
15. Carefully place the new H_2S scrubber in the end of the sensor body. If the O-ring came out, place it back in making sure it is seated in its groove.
16. Place the electrolyte reservoir assembly back in the sensor body making sure that the ridges on the electrolyte reservoir assembly line up with the grooves inside the sensor body.

CAUTION: *Verify that the electrolyte reservoir assembly is properly aligned before inserting it into the sensor body. Forcing an electrolyte reservoir assembly into its sensor body may damage the electrolyte reservoir assembly or the sensor body.*

17. Screw the collar of the ESM-01 sensor back on.
18. Plug the ESM-01 sensor back into the cable.
19. Insert the sensor into the ESM-01 flow chamber and push it in until it bottoms out.

20. Line up the holes in the ESM-01 sensor bracket with the two standoffs on the ESM-01 chamber.
21. Install the two sensor bracket screws.
22. Confirm that the main PCB is seated in its slots and that its bottom edge is resting on the bottom of the bottom case. If the main PCB is not seated properly, it may be damaged when the top case is re-installed.
23. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
24. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.
25. Calibrate the ESM-01 channel as described in “ESM-01 Calibration” on page 167.

Parts List

Table 19: ESM-01 EAGLE 2 Parts List

Part Number	Description
33-7120RK	H_2S scrubber disk, for ESM-01DH-D-HCN sensor
33-7121RK	H_2S scrubber disk, for ESM-01DH-F-SO2 sensor
47-5015RK	ESM-01 sensor cable
ESM-01DH-ASH3	Arsine sensor, 0-1.50 ppm
ESM-01R-NH3	Ammonia sensor, 0-75.0 ppm
ESM-01DH-D-HCN	Hydrogen cyanide sensor, 0-15.0 ppm
ESM-01DH-PH3	Phosphine sensor, 0-1.00 ppm
ESM-01DH-F-SO2	Sulfur dioxide sensor, 0-6.00 ppm
ESM-K01-CL2	Chlorine sensor, 0-3.00 ppm
81-0170RK-02	Calibration cylinder, 5 ppm SO_2 in nitrogen, 58 liter
81-0170RK-04	Calibration cylinder, 5 ppm SO_2 in nitrogen, 34 liter
81-0175RK-02	Calibration cylinder, 10 ppm NH_3 in nitrogen, 58 liter
81-0175RK-04	Calibration cylinder, 10 ppm NH_3 in nitrogen, 34 liter
81-0185RK-02	Calibration cylinder, 0.5 ppm PH_3 in nitrogen, 58 liter

Part Number	Description
81-0192RK-02	Calibration cylinder, 2 ppm Cl_2 in nitrogen, 58 liter
81-0192RK-04	Calibration cylinder, 2 ppm Cl_2 in nitrogen, 34 liter
81-0196RK-02	Calibration cylinder, 10 ppm HCN in nitrogen, 58 liter
81-0196RK-04	Calibration cylinder, 10 ppm HCN in nitrogen, 34 liter

Appendix F: TC Sensors

Overview

The TC sensors are used to monitor high levels of combustible gas. This appendix describes the EAGLE 2's TC sensor and includes instructions to use an EAGLE 2 that has a TC sensor installed. It also includes instructions to calibrate and replace a TC sensor.

Table 20: TC Sensor Specifications

Target Gas	Detection Range	Reading Increment	Alarm 1 Factory Setting	Alarm 2 Factory Setting	STEL	TWA
Methane (CH_4)	0 - 100.0 %vol	0.5 %vol	OFF	OFF	OFF	OFF
Hydrogen (H_2)	0 - 100.0 %vol	0.5 %vol	10.0 %vol	50.0 %vol	OFF	OFF
Hydrogen (H_2)	0 - 10.0 %vol	0.1 %vol	1.0 %vol	5.0 %vol	OFF	OFF

Description

The TC sensor is installed in a single sensor flow chamber which is located in the area next to the standard 4-sensor flow chamber. This area can accommodate up to three single sensor flow chambers. Figure 37 below illustrates a typical TC sensor location in front of the pump. The TC flow chamber may also be installed in one of the other two sensor chamber locations depending on the particular version of the EAGLE 2. Some TC sensor instrument configurations do not include the 4-sensor flow chamber.

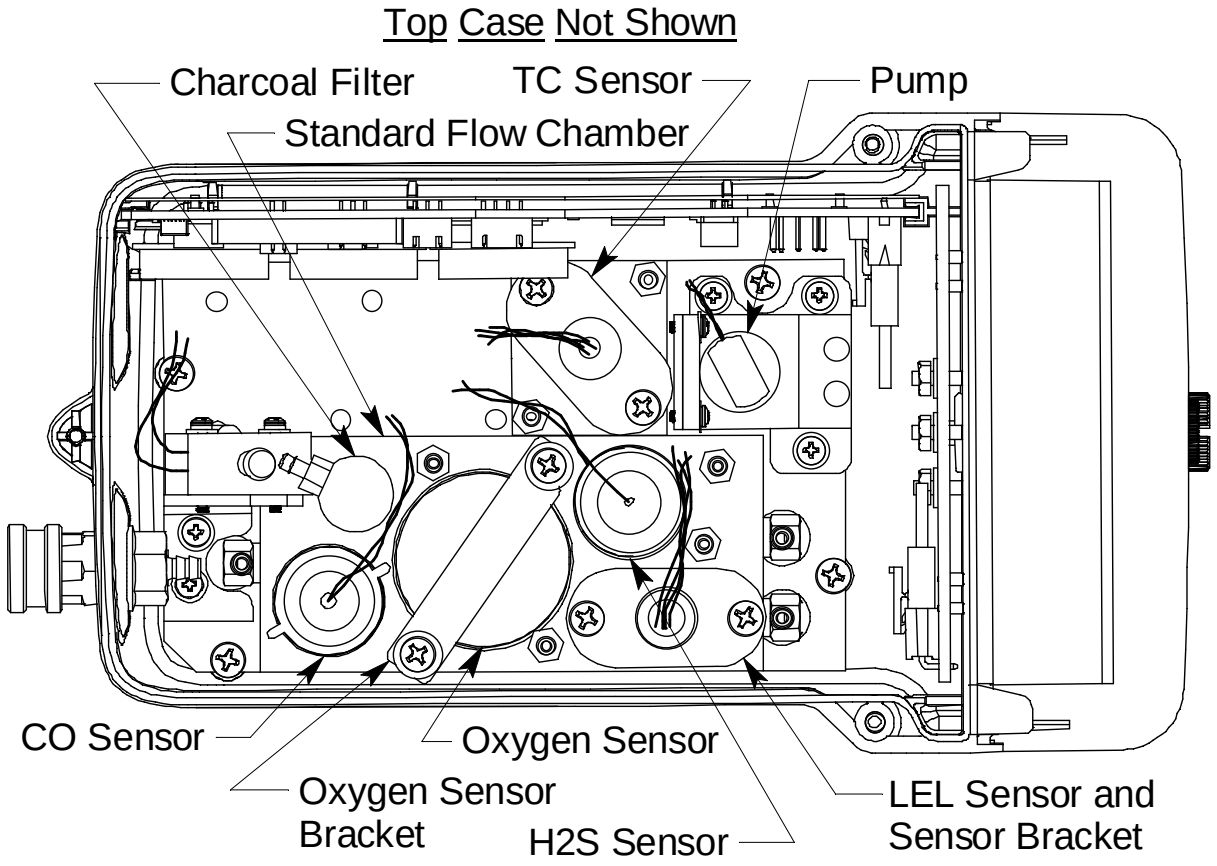


Figure 37: Typical TC Sensor Location

TC Sensor

The TC sensor's appearance is exactly the same as that of the LEL sensor. Its housing includes a sintered metal flame arrestor on one end that allows gas to diffuse into the sensor. On the other end, five pins extend from the sensor. The TC sensor can be distinguished from the LEL sensor by the part number imprinted on it. The TC sensor part number is TE-7568 while the LEL part number is NC-6260B. The sensor cable connects to pins on one end and terminates in a four-position connector on the other end which plugs into the TC sub PCB (see description below). The sensor bracket is installed over the TC sensor to keep it seated in place.

NOTE: The LEL and TC sensors and sensor cables are identical in appearance. Take care not to plug the LEL sensor cable into the port on the TC sub PCB and not to plug the TC sensor cable into the LEL port on the main PCB.

TC Sub PCB

The TC sub PCB is a circuit board that is installed on the main PCB in

one of the 3 sub PCB positions when a TC sensor is used with the EAGLE 2. The TC sensor cable connects to the sub PCB. The sub PCB plugs into the main PCB and is held in place with a screw / flat washer / lock washer. There are no user serviceable parts on the TC sub PCB.

Start Up and Normal Operation

For instructions to startup and use an EAGLE 2 that includes a TC sensor, reference "Start Up" on page 22, "Measuring Mode, Normal Operation" on page 29, and "Measuring Mode, Alarms" on page 34. Follow these instructions keeping the following in mind:

- The TC sensor is used to monitor combustible gases above their LEL (lower explosive limit). When monitoring the target gas in %volume, be aware that you may be monitoring gas levels that are potentially explosive.

Catalytic (LEL) Sensor Screen

When either a TC sensor or an infrared combustible sensor is installed in an EAGLE 2 along with a catalytic combustible LEL sensor, the user has the option of turning off the catalytic combustible LEL sensor in Display Mode. If the unit is going to be used for sampling known high-levels of combustible gas or in areas with known catalytic sensor poisons such as silicone vapors, the catalytic combustible sensor should be turned off. Even though this sensor has its own protective shut off, exposure to high levels of combustible gas can still stress the catalytic LEL sensor. The catalytic LEL sensor can be enabled or disabled in the Catalytic (LEL) Sensor screen in Display Mode. The default setting is enabled. To change the setting, do the following:

NOTE: The Catalytic (LEL) Sensor setting is reset when the EAGLE 2 is turned off. When the EAGLE 2 is turned on, this setting is always ENABLED.

1. Use the DISPLAY ADJUST NO button to enter Display Mode and scroll to the Catalytic (LEL) Sensor screen. The current setting will be flashing. The screen below indicates the warning that appears when a TC sensor and a catalytic LEL sensor are both installed. Since the TC sensor only reads in %volume, if the catalytic LEL sensor is disabled, there will be no alarms for the LEL range.

CAT (LEL) SENSOR * * * WARNING * * * NO LEL ALARMS IF CAT (LEL) IS DISABLED ENABLED

2. Use the AIR ▲ YES or RANGE ▼ SHIFT button to toggle to the desired setting.

   If set to DISABLED, the gas reading for the catalytic LEL channel will be replaced by dashes (---).

3. Press and release POWER ENTER RESET to save the setting and return to the main menu.
4. Use the DISPLAY ADJUST NO button to scroll through the rest of Display Mode and enter Normal Operation.

TC Calibration

A TC channel can be calibrated using the auto calibration method or the single calibration method. To calibrate a TC channel using the single calibration method, see “Calibrating Using the Single Calibration Method” on page 63 and follow the instructions for calibrating a single channel. If your instrument is a multi-channel instrument that includes one or more TC channels, RKI Instruments, Inc. recommends using the auto calibration method for convenience. The calibration instructions below show a 5 channel instrument which has the four standard channels, LEL / oxygen / H_2S / CO, and a TC channel configured for 0-100 %vol CH_4. To use the auto calibration method to calibrate a multi-channel instrument that includes a TC channel, do the following:

1. See “Calibration Supplies and Equipment” on page 56 for a description of the necessary calibration supplies. In addition to an appropriate multi-gas cylinder that is used to calibrate any active standard channels, you will also need a cylinder to calibrate the TC channel. See Table 21 on

page 200 for available cylinders. Make sure your calibration cylinder is appropriate for the TC detection range.

If the EAGLE 2 is intended for use in a landfill, RKI Instruments, Inc. recommends using the carbon dioxide/methane mix calibration cylinder because it is representative of gases present in a landfill.

NOTE: If your instrument has more than one TC sensor, you will need a calibration cylinder for each sensor.

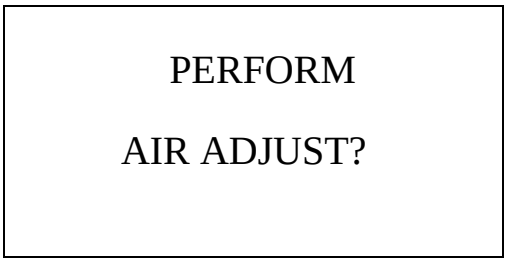
2. Find a fresh-air environment. This is an environment free of toxic or combustible gases and of normal oxygen content (20.9%).
3. While in Measuring Mode, press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both buttons.
4. If the unit prompts you for the password, enter it by using the AIR ▲ YES and RANGE ▼ SHIFT buttons to select each password number and then pressing and releasing POWER ENTER RESET to enter the number and move on to the next one.
5. The Calibration Mode Screen displays with the cursor next to **AUTO CALIBRATION**.

```
CALIBRATION MODE

> AUTO CALIBRATION
  SINGLE CALIBRATION
  PERFORM AIR ADJUST
  NORMAL OPERATION
```

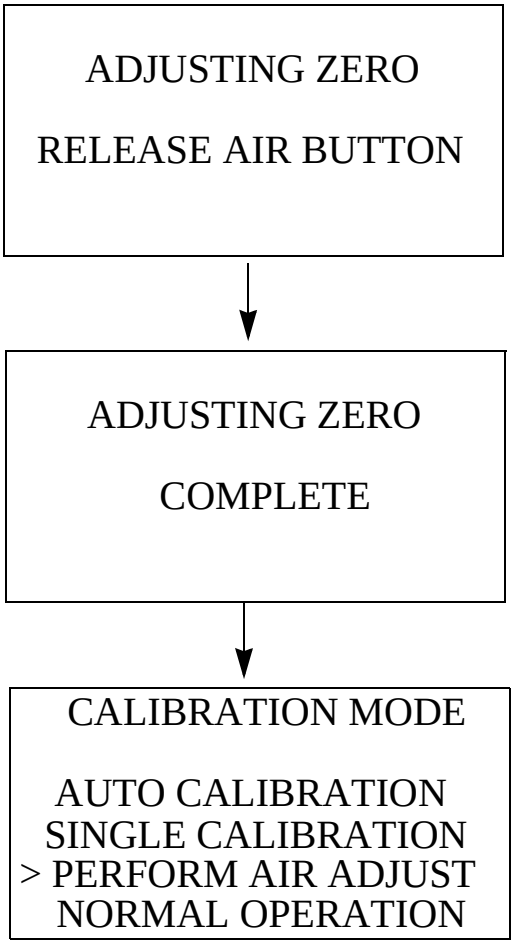
6. Move the cursor to the **PERFORM AIR ADJUST** menu item by using the RANGE ▼ SHIFT button.

```
CALIBRATION MODE

  AUTO CALIBRATION
  SINGLE CALIBRATION
> PERFORM AIR ADJUST
  NORMAL OPERATION
```

7. Press and release the POWER ENTER RESET button. The following screen appears.



8. Press and release the AIR ▲ YES button to continue.
   If you do not want to continue, press the DISPLAY ADJUST NO button and the unit will return to the Calibration Mode Screen.
9. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.



10. Install the demand flow regulator onto the multi-gas calibration cylinder.
11. Connect the sample tubing to the demand flow regulator.
12. Install the probe on the EAGLE 2 inlet fitting. Make sure the probe is

complete with internal O-ring and membrane and that the two halves of the probe are tightened firmly together to avoid leaks that can affect the calibration. See Figure 20, “Replacing the Hydrophobic Filter Disk & O-ring” on page 73 for an illustration of the internal parts of the probe.

13. Move the cursor next to the **AUTO CALIBRATION** menu item by using the AIR ▲ YES button.

CALIBRATION MODE
> AUTO CALIBRATION
SINGLE CALIBRATION
PERFORM AIR ADJUST
NORMAL OPERATION

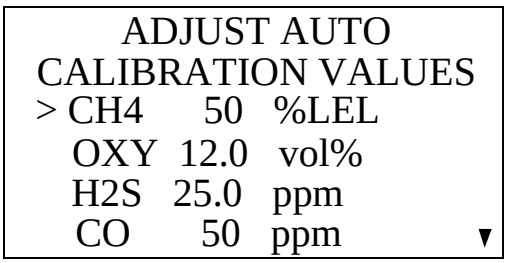
14. Press and release the POWER ENTER RESET button to display the Calibration Gas Values Screen.

CAL GAS VALUES		
CH4	50	%LEL
OXY	12.0	vol%
H2S	25.0	ppm
CO	50	ppm
ENTER TO BEGIN CAL		

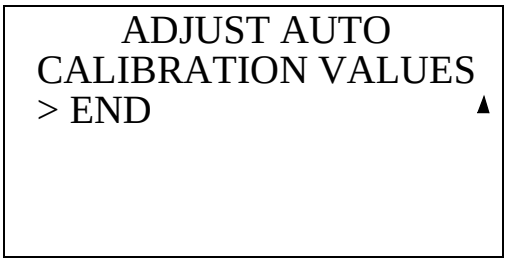
The gas concentrations displayed in the Calibration Gas Values Screen must match the gas concentrations listed on the 4-gas calibration cylinder.
If *all* concentrations match, go to Step 25.
If *one or more* concentrations *do not* match, continue with Step 15.
If you do not want to continue with the calibration, press and release the DISPLAY ADJUST NO button to return to the Calibration Mode Screen.

NOTE: The RKI 4-gas cylinder typically contains 12% O_2 by volume. When using the auto calibration method, be sure to set the “OXY” auto calibration value to agree with the concentration listed on the cylinder’s label, not zero.

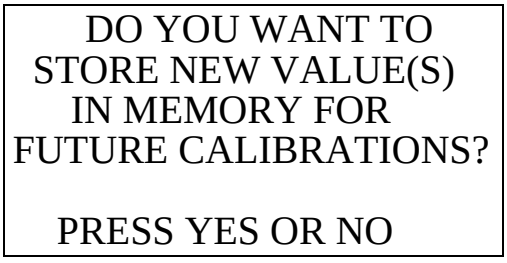
15. To adjust the values on the screen, press and hold the RANGE ▼SHIFT button, then press the DISPLAY ADJUST NO button and release both. The following screen appears with the cursor next to **CH4**.



16. Place the cursor next to the channel whose gas value you want to change using the AIR ▲ YES and RANGE ▼SHIFT buttons.
17. Press and release the POWER ENTER RESET button to select the channel. The calibration gas value begins to flash.
18. Use the AIR ▲ YES and RANGE ▼SHIFT buttons to adjust the calibration gas setting to the desired value.
19. Press and release the POWER ENTER RESET button to save the change. The calibration gas value stops flashing.
20. Repeat Step 16 through Step 19 for any other channels that need to be changed.
21. When you are done adjusting the calibration gas values, move the cursor down past the bottom of the screen next to **END**.



22. Press and release the POWER ENTER RESET button. The following screen appears.



23. If you select YES by pressing and releasing the AIR ▲ YES button, the changes that you made will be saved in the EAGLE 2's memory as the

new auto calibration gas values.

If you select NO by pressing and releasing the DISPLAY ADJUST NO button, the changes you made will be used for any calibrations performed during the current operating session only. The EAGLE 2 will delete the changes when the unit is turned off and will load the previous set of auto calibration values when it is turned on again.

24. When you make your selection and press the desired button, the unit returns to the Calibration Gas Values Screen.

CAL GAS VALUES		
CH4	50	%LEL
OXY	12.0	vol%
H2S	25.0	ppm
CO	50	ppm
ENTER TO BEGIN CAL		

25. Press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen with **CAL IN PROCESS** flashing.

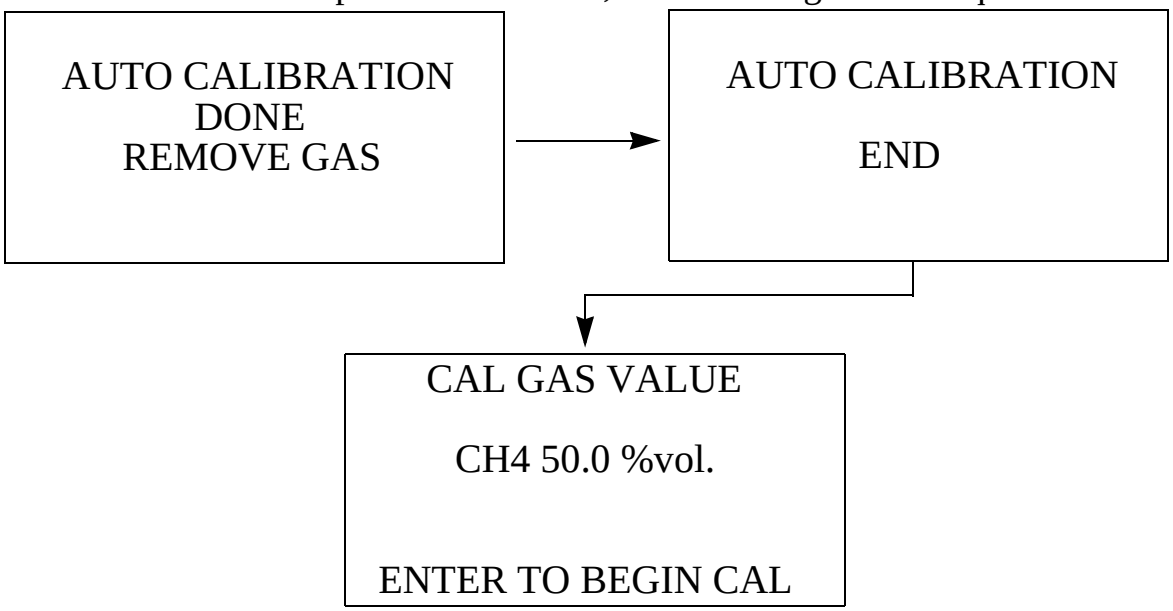
CAL IN PROCESS		
CH4	0	%LEL
OXY	20.9	vol%
H2S	0.0	ppm
CO	0	ppm
ENTER WHEN DONE		

If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the Cal Gas Values Screen.

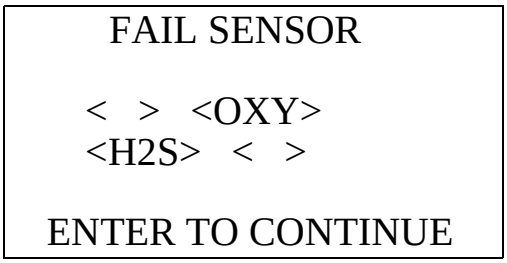
If you do want to continue with the calibration, proceed to the next step.

26. Connect the tubing from the demand flow regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for one minute.
27. Press and release the POWER ENTER RESET button to set the span adjustment for each channel to the programmed values.

28. If all channels passed calibration, the following screen sequence occurs.



If any of the sensors cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and lists the sensor(s) that failed to calibrate. In the example below, the oxygen and H_2S channels failed calibration. The other sensors calibrated normally.

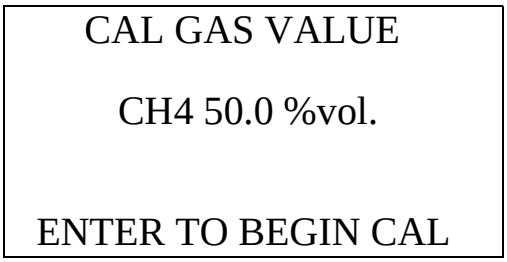


The buzzer and alarm LEDs activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and continue to the Calibration Value Screen for the TC channel. After calibrating the TC channel by following the instructions below, attempt to calibrate the standard channels again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

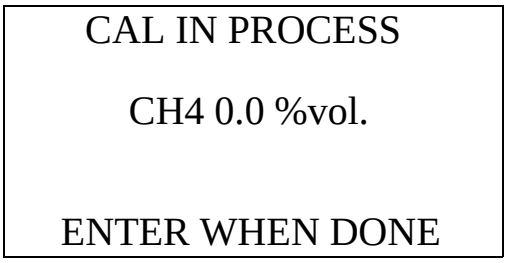
29. Remove the tubing from the rigid tube on the probe.

30. Unscrew the 4-gas cylinder from the demand flow regulator.

31. If you want to change the TC channel's calibration gas value, follow Step 15 - Step 24 above beginning with the TC Calibration Gas Value Screen below instead of the standard channel Calibration Gas Value Screen.



32. With the TC Calibration Gas Value Screen displayed, press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen for the TC channel with **CAL IN PROCESS** flashing.

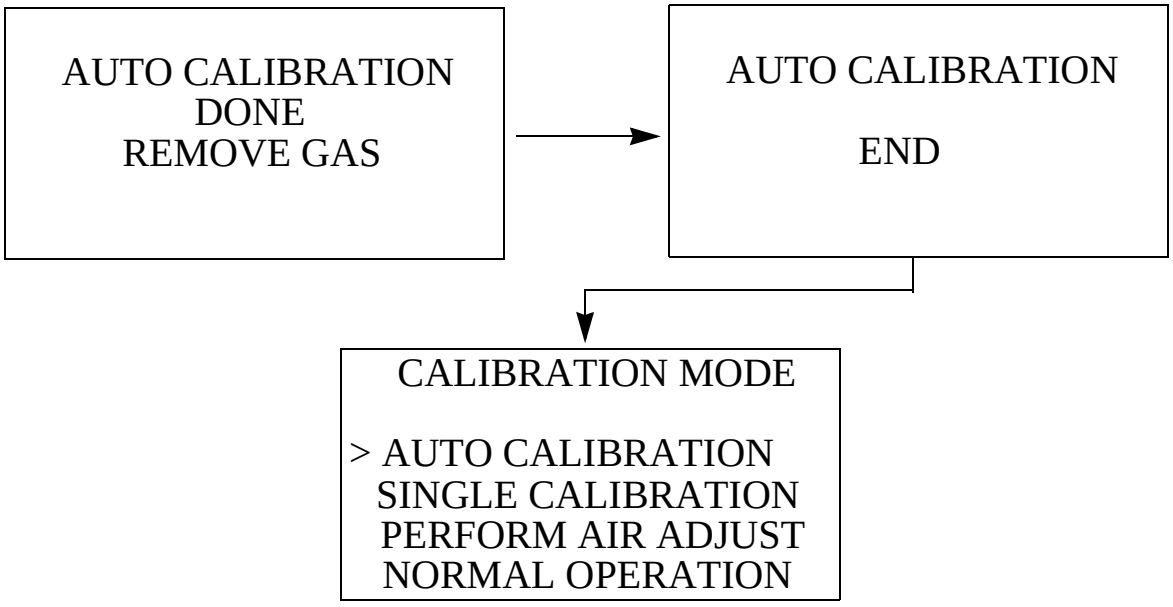


If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the TC Cal Gas Values Screen.

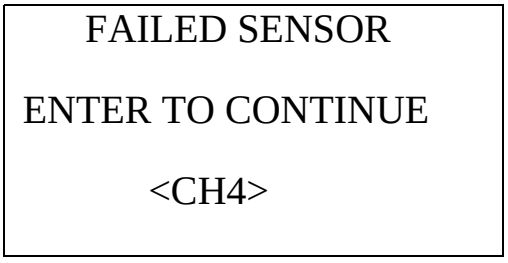
If you do want to continue with the calibration, proceed to the next step.

33. Screw the new TC calibration cylinder onto the demand flow regulator.
34. Connect the tubing from the regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for one minute.
35. Press and release the POWER ENTER RESET button to set the span adjustment for the TC channel to the programmed value.

36. If the TC channel passed calibration, the following screen sequence occurs.



If the TC channel cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and indicates that the TC sensor failed to calibrate.



The buzzer and alarm LEDs activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and continue to the Calibration Mode Screen. Attempt to calibrate the TC channel again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

37. Disconnect the tubing from the probe.
38. Unscrew the demand flow regulator from the calibration cylinder.
39. Use the RANGE ▼SHIFT button to place the cursor next to the **NORMAL OPERATION** menu option, then press and release the POWER ENTER RESET button to return to Measuring Mode.

The TC sensor does not include any user serviceable parts. This section includes a procedure for replacing the TC sensor.

Replacing the TC Sensor

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main PCB with the cable that connects the top case to the main PCB.
5. Lay the top case down next to the bottom case to allow access to the flow system.
6. Locate the TC sensor. It has a five wire cable with a connector that mates to a TC sub PCB that is installed on the main PCB and is normally located in a single sensor flow chamber next to the pump. Figure 37 on page 183 shows a TC sensor in a typical location.
7. Unscrew and remove the two screws that hold down the TC sensor bracket.
8. Grasp the TC sensor connector and gently pull it up until it either disengages from the TC sensor or the TC sensor comes out of the flow chamber with the connector.
9. If the sensor came out with the connector, remove the sensor from the connector.
10. If the sensor stayed in the flow chamber, grasp the sensor and pull it out of the flow chamber.
11. Plug the replacement sensor into the sensor connector on the TC sensor cable.
12. Insert the TC sensor into the TC sensor chamber in the flow chamber.
13. Line up the holes in the TC sensor retaining bracket with the two standoffs on either side of the TC sensor chamber.
14. Install the two sensor retaining screws tightening them a little at a time alternately to push the sensor into its chamber evenly.
15. Confirm that the main PCB is seated in its slots and that its bottom edge is resting on the bottom of the bottom case. If the main PCB is not seated

properly, it may be damaged when the top case is reinstalled.

16. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
17. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.
18. Calibrate the TC channel as described in “TC Calibration” on page 185.

Configuring the TC Gas in Setup Mode

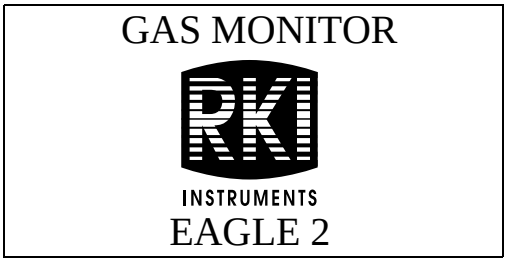
The TC channel can be configured for 3 different pre-defined gases and 1 user-defined gas in the CONFIGURE GASES menu item in Setup Mode. To change the gas configuration of the TC channel in Setup Mode, do the following:

WARNING: Do not use the user defined gas configuration without consulting RKI Instruments, Inc.

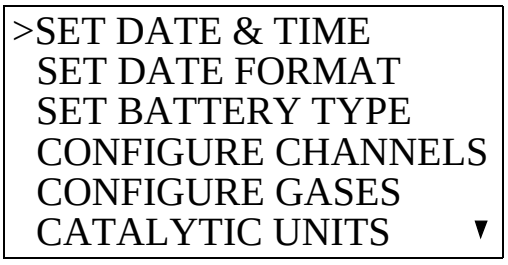
WARNING: The EAGLE 2 is not in operation as a gas detector while in Setup Mode.

1. Take the EAGLE 2 to a non-hazardous location and turn it off if it is on.
2. Press and hold AIR ▲ YES and RANGE ▼ SHIFT, then press and hold POWER ENTER RESET. When you hear a beep, release the buttons.
3. The LCD will show the following screen for a few seconds with the “S” in the lower right corner indicating the unit is entering Setup Mode.

4. The “S” will then disappear and the following screen will appear for a few seconds.

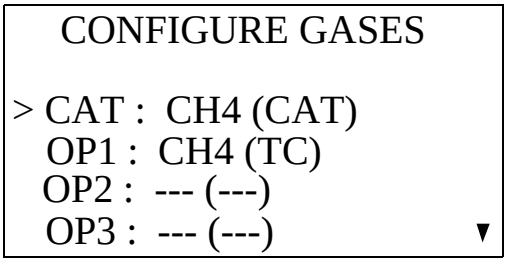


5. If the unit prompts you for the password, enter it by using AIR ▲ YES and RANGE ▼SHIFT to select each password number and then pressing and releasing the POWER ENTER RESET button to enter it and move on to the next number until all of the numbers are entered. The main menu displays. It displays six menu items at a time.



6. Use the RANGE ▼SHIFT button to move the cursor down the menu to CONFIGURE GASES.

7. Press and release POWER ENTER RESET. The Configure Gases Screen appears with the cursor flashing next to CAT, the catalytic sensor. If an EAGLE 2 has a TC sensor installed, one of the three optional sensor types, OP1, OP2, or OP3 will indicate it is a TC. In the example below, OP1 is shown as a TC sensor.



8. Use RANGE ▼ SHIFT to move the cursor down the menu to the TC sensor.

```
   CONFIGURE GASES

  CAT :  CH4 (CAT)
> OP1 :  CH4 (TC)
  OP2 :  --- (---)
  OP3 :  --- (---)                ▼
```

9. To change the TC sensor gas configuration, press and release POWER ENTER RESET.

10. A screen appears that indicates the detection range for the currently configured gas. In the example below, the TC sensor is currently configured for 0 - 100 %volume CH_4. The screen also shows the gas configuration choices for the TC sensor. There are 3 pre-defined options and 1 user-defined option. The user-defined option will always have an asterisk next to it.

```
 TC (0-100.0vol%CH4)

>  100.0 vol% CH4
   100.0 vol% H2
    10.0 vol% H2
    10.0 vol% TC              * ▼
```

11. Use AIR ▲ YES and RANGE ▼ SHIFT to move the cursor next to the desired gas.

12. If you placed the cursor next to one of the pre-defined gases, press and release POWER ENTER RESET to select the gas and proceed to Step 17.

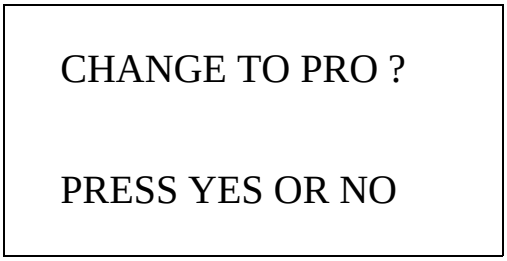
    If you placed the cursor next to the user defined gas with the asterisk (*), press POWER ENTER RESET and proceed with Step 13.

13. The user defined gas setup screen appears with the first character of the gas name flashing. The current gas name and range are shown on the top line of the screen.

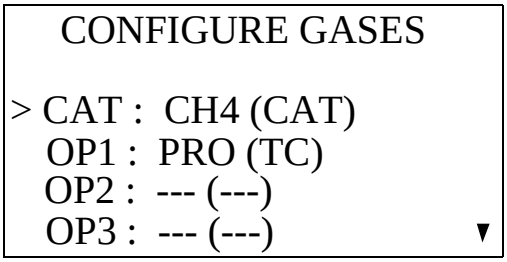
```
   TC (0-100.0vol%CH4)
   CHANGE TO NAME
         TC

FULL_SCALE          10.0
```

WARNING: Do not use the user defined gas configuration without consulting RKI Instruments, Inc.

14. Enter the gas name. There are 3 characters available for the gas name. The factory setting of TC uses only 2 characters. Use AIR ▲ YES and RANGE ▼ SHIFT to display the desired character, then press POWER ENTER RESET to enter the displayed character and move to the next character. Repeat until all three characters are entered. When the last character is entered, the full scale value will be flashing.
15. Use AIR ▲ YES and RANGE ▼ SHIFT to display the desired full scale value. It may be any value from 10 to 100 in increments of 10.
16. Press and release POWER ENTER RESET to enter the full scale value. The confirmation screen appears. In the example below, the user defined gas has been selected and defined as propane with the gas name set to PRO.



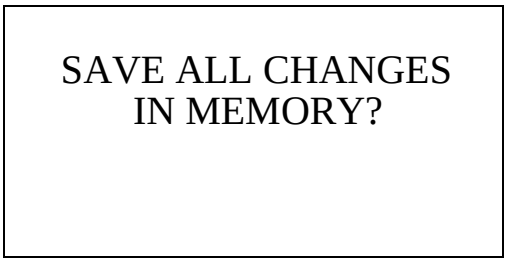
17. If you want to accept the gas configuration change, press and release AIR ▲ YES. The unit will return to the Configure Gases screen.



If you do not want to accept the gas configuration change, press and release DISPLAY ADJUST NO to return to the screen with the gas choices shown in Step 10 on page 197. You can either scroll down to END and press POWER ENTER RESET to return to the Configure Gases screen or continue from Step 10 on page 197 to select a new gas.

18. Use RANGE ▼ SHIFT to place the cursor next to **END**.
19. Press and release POWER ENTER RESET to return to the main menu.
20. Use RANGE ▼ SHIFT to place the cursor in front of **NORMAL OPERATION** at the bottom of the main menu.

21. Press and release POWER ENTER RESET.
22. A screen appears that asks if you want to save the changes you have made.



NOTE: If you entered Setup Mode and did not make any changes, the above screen will still appear. In this case, press and release DISPLAY ADJUST NO to proceed to exit Setup Mode and begin the EAGLE 2's startup sequence.

23. If you do not want to save the changes, press and release DISPLAY ADJUST NO. The unit will begin its startup sequence without saving the changes.

    If you do want to save the changes, press and release AIR ▲ YES and continue with the next step.
24. A confirmation screen appears asking if you are sure you want to save the changes.

25. If you want to save the changes, press and release AIR ▲ YES to save the changes. A screen will appear for a few seconds indicating that the changes have been saved and the unit will begin its startup sequence.

    If you do not want to save the changes, press and release DISPLAY ADJUST NO to proceed to the unit's startup sequence without saving changes.

Parts List

Table 21: TC EAGLE 2 Parts List

Part Number	Description
47-5010RK	TC/LEL sensor cable
TE-7568	TC sensor
81-0013RK-01	Calibration cylinder, 50% vol CH_4 in N_2, 34 liter steel
81-0013RK-05	Calibration cylinder, 50% vol CH_4 in N_2, 58 liter steel
81-0023RK-01	Calibration cylinder, H_2, 8% volume in nitrogen, 34 liter steel
81-0024RK-01	Calibration cylinder, H_2, 100% volume, 34 liter steel
81-0025RK-01	Calibration cylinder, 35% CO_2/50% CH_4, balance N_2, 34 liter steel, intended for landfill applications

Appendix G: Infrared Carbon Dioxide Sensors

Overview

The infrared CO_2 sensors are used to monitor levels of carbon dioxide. This appendix describes the EAGLE 2's infrared CO_2 sensors and includes instructions to use an EAGLE 2 that has one or more infrared CO_2 sensors installed. It also includes instructions to replace an infrared CO_2 sensor.

Table 22: Infrared CO_2 Sensor Specifications

Range	Increment	Alarm 1 Factory Setting	Alarm 2 Factory Setting	STEL (ppm)	TWA (ppm)
0-5.00 %vol	0.02 %vol	0.5 %vol	3.0 %vol	3.0	0.5
0-10,000 ppm	25 ppm	5,000 ppm	OFF	5,000	OFF
0-60.0 %vol	0.2 %vol	OFF	OFF	OFF	OFF

Description

Table 22 above lists the available infrared CO_2 sensors. The infrared CO_2 sensor is a smart sensor that stores sensor parameters including the target gas and detection range. So you can change an existing infrared CO_2 channel from one range to another and the EAGLE 2 will automatically load all the sensor parameters and configure the infrared CO_2 channel for the new sensor without the need to enter CONFIGURE CHANNELS or CONFIGURE GASES in Setup Mode. See "Replacing the IR CO_2 Sensor or Changing Sensor Type" on page 213 for instructions to replace or change an infrared CO_2 sensor.

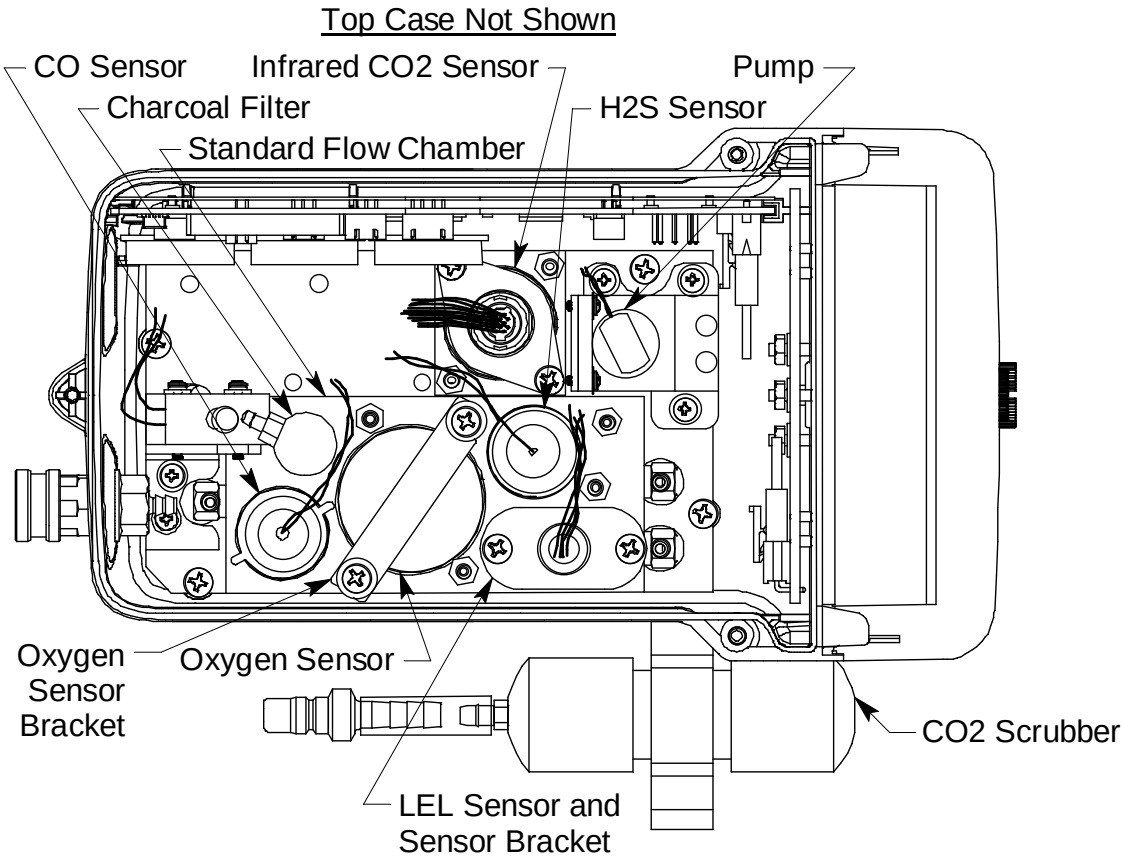


Figure 38: Typical Infrared CO_2 Sensor Location

The infrared CO_2 sensor is installed in a single sensor flow chamber which is located in the area next to the standard 4-sensor flow chamber. This area can accommodate up to three single sensor flow chambers. Figure 38 above illustrates a typical infrared CO_2 sensor location in front of the pump. The infrared CO_2 flow chamber may also be installed in one of the other two sensor chamber locations depending on the particular version of the EAGLE 2. Some infrared CO_2 instrument configurations do not include the 4-sensor flow chamber.

Infrared CO_2 Sensor

The infrared CO_2 sensor is a cylindrical sensor with a diffusion opening on the front and a 12 pin circular connector on the back. A 12 wire cable plugs into the back of the infrared CO_2 sensor with a circular connector that includes a locking lever. The other end of the cable plugs into an infrared sub PCB (see description below) that is installed on the main PCB. The sensor is held in the infrared flow chamber by a bracket on standoffs.

Infrared Sub PCB

The infrared sub PCB is a circuit board that is installed on the main PCB in one of the 3 sub PCB positions when an infrared CO_2 sensor is used with the EAGLE 2. The infrared CO_2 sensor connects to the sub PCB with a 12-position connector. The sub PCB plugs into the main PCB and is held in place with a screw / flat washer / lock washer. There are no user serviceable parts on the infrared sub PCB.

CO_2 Scrubber

A carbon dioxide scrubber is mounted to the exterior side of EAGLE 2s that are factory-shipped with carbon dioxide sensors for the ranges of 0-5 %vol and 0-10,000 ppm.

NOTE: EAGLE 2s with a range of 0-60 %vol CO_2 do not include a scrubber since the normal background of CO_2 in air is negligible when compared to the full scale of these units.

This scrubber is for use when setting the carbon dioxide sensor's zero reading only. Replace the scrubber when it turns from white to a violet color.

Start Up and Normal Operation

For instructions to startup and use an EAGLE 2 that includes an infrared CO_2 sensor, reference "Start Up" on page 22, "Measuring Mode, Normal Operation" on page 29, and "Measuring Mode, Alarms" on page 34. Follow these instructions keeping the following special considerations in mind:

- A background level of CO_2 exists in fresh air. The low range sensors will display a reading in fresh air. Table 23 below indicates typical gas readings in fresh air.

Table 23: Carbon Dioxide Fresh Air Readings

Sensor Range	Approximate Fresh Air Reading
0-5 %vol	0.04 %vol
0-10,000 ppm	400 ppm
0-60 %vol	0.0 %vol

- When you perform a demand zero during start up, operation, or

calibration of a 0-10,000 ppm or 0-5 %vol CO_2 instrument, you must use the CO_2 scrubber provided with the instrument to remove background CO_2 from the air being sampled. See "Performing a Demand Zero for Carbon Dioxide Sensors" below.

- Since there is a background of CO_2 in air, do not use the AUTO FRESH AIR ADJ feature that can be turned on and off in Setup Mode. The factory setting for the feature is off.

Performing a Demand Zero for Carbon Dioxide Sensors

When setting the zero reading, the carbon dioxide scrubber mounted to the side of the EAGLE 2 allows you to eliminate carbon dioxide normally found in fresh air. To perform a demand zero, do the following:

1. Connect the carbon dioxide scrubber directly to the EAGLE 2's inlet fitting.
2. Wait one minute for the fresh air sample to flow through the carbon dioxide scrubber, then press AIR ▲ YES to set the zero reading.
3. Remove the scrubber from the inlet fitting.

Infrared CO_2 Calibration

An infrared CO_2 channel can be calibrated using the auto calibration method or the single calibration method. To calibrate an infrared CO_2 channel using the single calibration method, see "Calibrating Using the Single Calibration Method" on page 63 and follow the instructions for calibrating a single channel. If your instrument is a multi-channel instrument that includes one or more infrared CO_2 channels, RKI Instruments, Inc. recommends using the auto calibration method for convenience. The calibration instructions below show a 5 channel instrument which has the four standard channels, LEL / oxygen / H_2S / CO, and an infrared CO_2 channel for 0-5 %vol. To use the auto calibration method to calibrate a multi-channel instrument that includes an infrared CO_2 channel, do the following:

NOTE: If your instrument has more than one infrared CO_2 sensor, you will need a calibration cylinder for each sensor.

1. See "Calibration Supplies and Equipment" on page 56 for a description of the necessary calibration supplies. In addition to an appropriate multi-gas cylinder that is used to calibrate any active standard channels, you

will also need a cylinder to calibrate the infrared CO_2 channel. See Table 25 on page 214 for available cylinders. Make sure your calibration cylinder is appropriate for the infrared CO_2 detection range.

2. Find a fresh-air environment. This is an environment free of toxic or combustible gases and of normal oxygen content (20.9%).
3. While in Measuring Mode, press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both buttons.
4. If the unit prompts you for the password, enter it by using the AIR ▲ YES and RANGE ▼ SHIFT buttons to select each password number and then pressing and releasing POWER ENTER RESET to enter the number and move on to the next one.
5. The Calibration Mode Screen displays with the cursor next to **AUTO CALIBRATION**.

```
CALIBRATION MODE

> AUTO CALIBRATION
  SINGLE CALIBRATION
  PERFORM AIR ADJUST
  NORMAL OPERATION
```

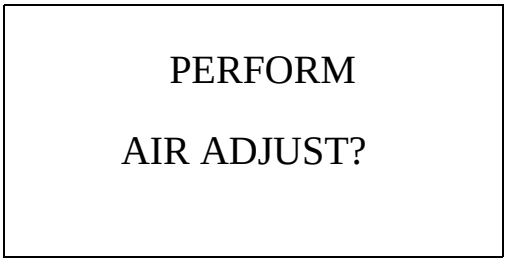
6. Move the cursor to the **PERFORM AIR ADJUST** menu item by using the RANGE ▼ SHIFT button.

```
CALIBRATION MODE

  AUTO CALIBRATION
  SINGLE CALIBRATION
> PERFORM AIR ADJUST
  NORMAL OPERATION
```

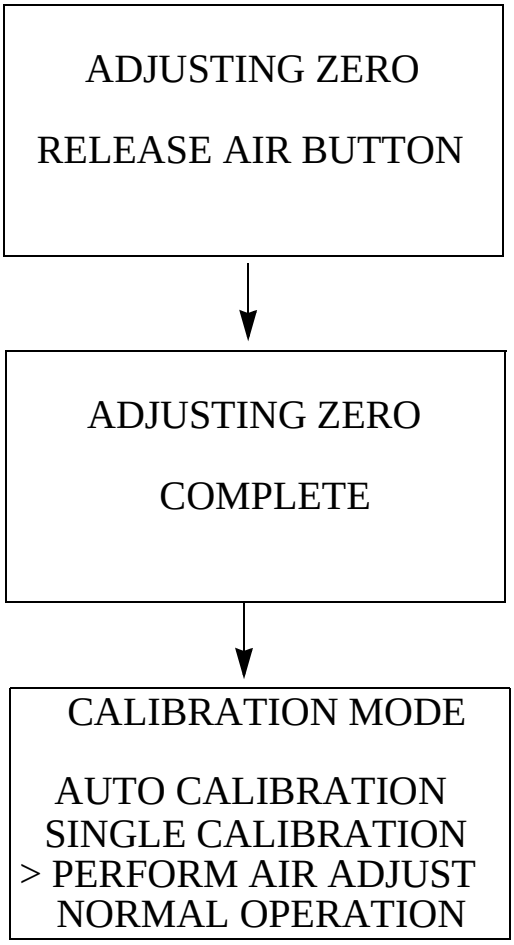
7. Attach the CO_2 scrubber to the inlet fitting of the EAGLE 2 and allow the instrument to draw gas for 1 minute before performing an air adjust.

NOTE: Attaching the CO_2 scrubber to the inlet fitting eliminates the background CO_2 found in fresh air and allows the EAGLE 2 to obtain an accurate zero reading.

8. Press and release the POWER ENTER RESET button. The following screen appears.



9. Press and release the AIR ▲ YES button to continue.
   If you do not want to continue, press the DISPLAY ADJUST NO button and the unit will return to the Calibration Mode Screen.
10. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.



11. Remove the CO_2 scrubber from the EAGLE 2 inlet fitting.
12. Install the demand flow regulator onto the multi-gas calibration cylinder.
13. Connect the sample tubing to the demand flow regulator.

14. Install the probe on the EAGLE 2 inlet fitting. Make sure the probe is complete with internal O-ring and membrane and that the two halves of the probe are tightened firmly together to avoid leaks that can affect the calibration. See Figure 20, “Replacing the Hydrophobic Filter Disk & O-ring” on page 73 for an illustration of the internal parts of the probe.
15. Move the cursor next to the **AUTO CALIBRATION** menu item by using the AIR ▲ YES button.

```
CALIBRATION MODE

> AUTO CALIBRATION
  SINGLE CALIBRATION
  PERFORM AIR ADJUST
  NORMAL OPERATION
```

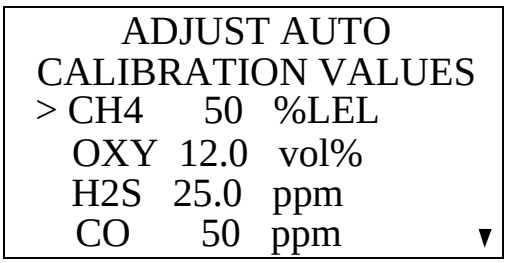
16. Press and release the POWER ENTER RESET button to display the Calibration Gas Values Screen.

```
CAL GAS VALUES
CH4     50  %LEL
OXY   12.0  vol%
H2S   25.0  ppm
CO      50  ppm
ENTER TO BEGIN CAL
```

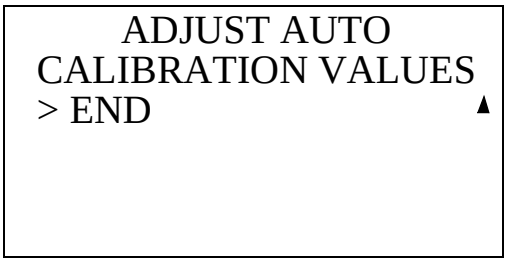
The gas concentrations displayed in the Calibration Gas Values Screen must match the gas concentrations listed on the 4-gas calibration cylinder.
If *all* concentrations match, go to Step 27.
If *one or more* concentrations *do not* match, continue with Step 17.
If you do not want to continue with the calibration, press and release the DISPLAY ADJUST NO button to return to the Calibration Mode Screen.

NOTE: The RKI 4-gas cylinder typically contains 12% O_2 by volume. When using the auto calibration method, be sure to set the “OXY” auto calibration value to agree with the concentration listed on the cylinder’s label, not zero.

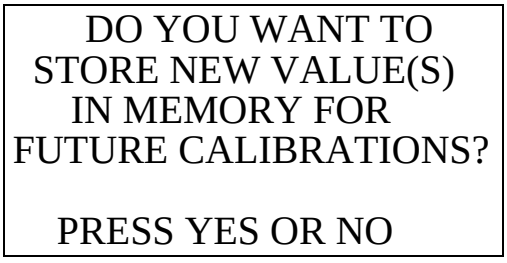
17. To adjust the values on the screen, press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both. The following screen appears with the cursor next to **CH4**.



18. Place the cursor next to the channel whose gas value you want to change using the AIR ▲ YES and RANGE ▼ SHIFT buttons.
19. Press and release the POWER ENTER RESET button to select the channel. The calibration gas value begins to flash.
20. Use the AIR ▲ YES and RANGE ▼ SHIFT buttons to adjust the calibration gas setting to the desired value.
21. Press and release the POWER ENTER RESET button to save the change. The calibration gas value stops flashing.
22. Repeat Step 17 through Step 21 for any other channels that need to be changed.
23. When you are done adjusting the calibration gas values, move the cursor down past the bottom of the screen next to **END**.



24. Press and release the POWER ENTER RESET button. The following screen appears.



25. If you select YES by pressing and releasing the AIR ▲ YES button, the changes that you made will be saved in the EAGLE 2's memory as the

new auto calibration gas values.

If you select NO by pressing and releasing the DISPLAY ADJUST NO button, the changes you made will be used for any calibrations performed during the current operating session only. The EAGLE 2 will delete the changes when the unit is turned off and will load the previous set of auto calibration values when it is turned on again.

26. When you make your selection and press the desired button, the unit returns to the Calibration Gas Values Screen.

CAL GAS VALUES		
CH4	50	%LEL
OXY	12.0	vol%
H2S	25.0	ppm
CO	50	ppm
ENTER TO BEGIN CAL		

27. Press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen with **CAL IN PROCESS** flashing.

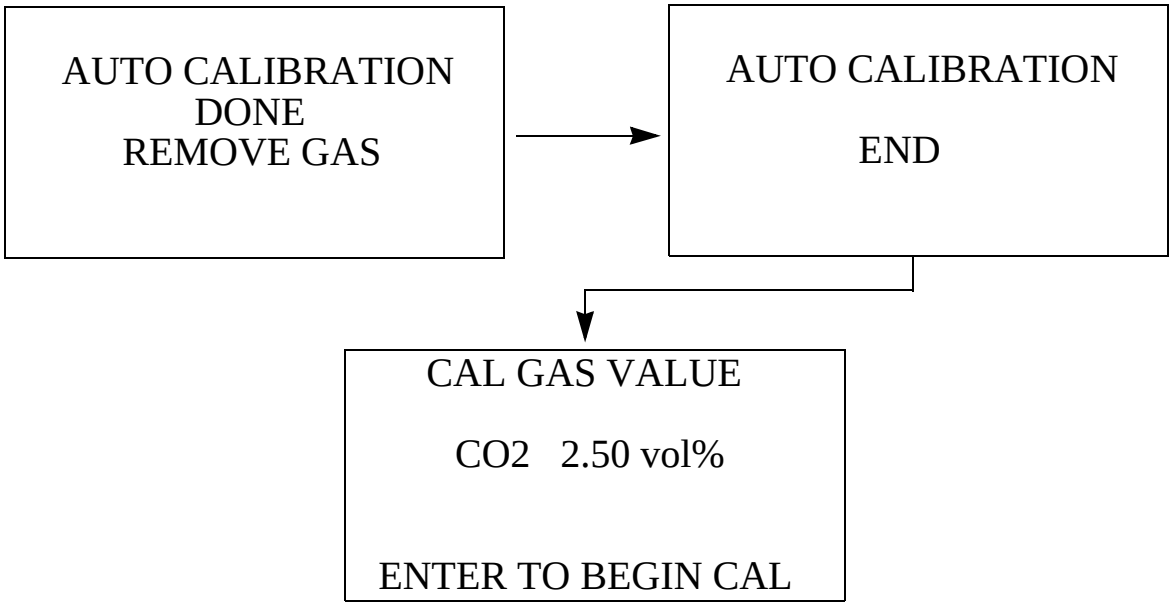
CAL IN PROCESS		
CH4	0	%LEL
OXY	20.9	vol%
H2S	0.0	ppm
CO	0	ppm
ENTER WHEN DONE		

If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the Cal Gas Values Screen.

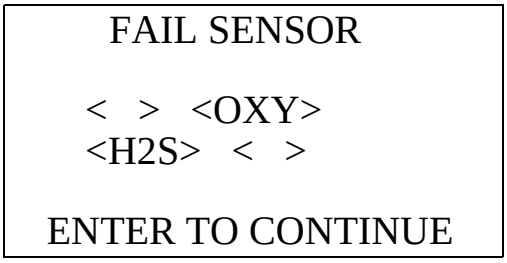
If you do want to continue with the calibration, proceed to the next step.

28. Connect the tubing from the demand flow regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for one minute.
29. Press and release the POWER ENTER RESET button to set the span adjustment for each channel to the programmed values.

30. If all channels passed calibration, the following screen sequence occurs.



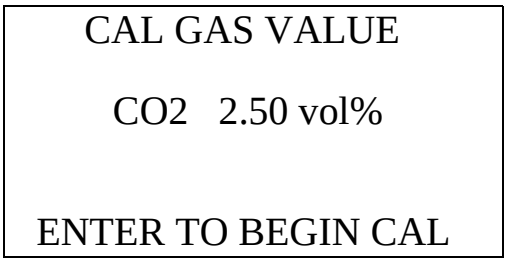
If any of the sensors cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and lists the sensor(s) that failed to calibrate. In the example below, the oxygen and H_2S channels failed calibration. The other sensors calibrated normally.



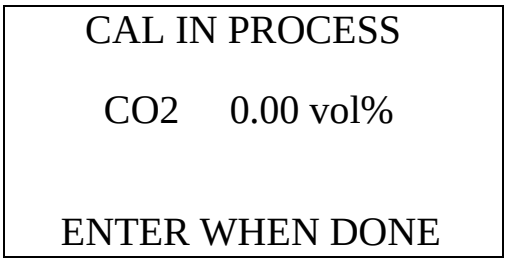
The buzzer and alarm LEDs activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and continue to the Calibration Value Screen for the infrared CO_2 channel. After calibrating the infrared CO_2 channel by following the instructions below, attempt to calibrate the standard channels again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

31. Remove the tubing from the rigid tube on the probe.
32. Unscrew the 4-gas cylinder from the demand flow regulator.
33. If you want to change the infrared CO_2 channel’s calibration gas value, follow Step 17 - Step 26 above beginning with the infrared CO_2 Calibration Gas Value Screen below instead of the standard channel

Calibration Gas Value Screen.



34. With the infrared CO_2 Calibration Gas Value Screen displayed, press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen for the infrared CO_2 channel with **CAL IN PROCESS** flashing.



If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the infrared CO_2 Cal Gas Values Screen.

If you do want to continue with the calibration, proceed to the next step.

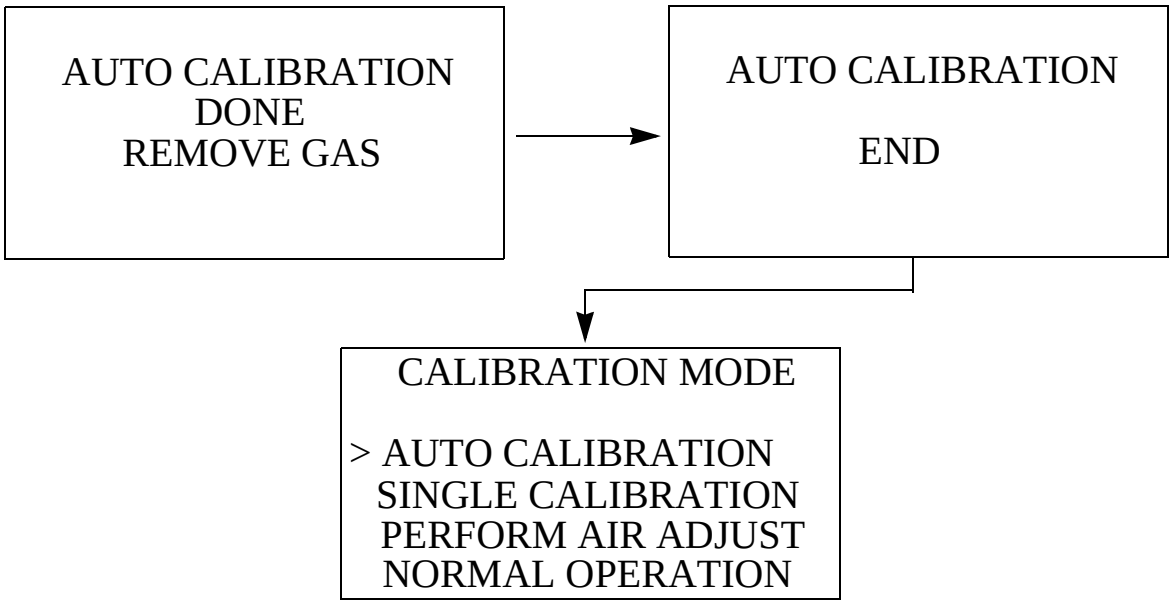
35. Screw the infrared CO_2 calibration cylinder onto the demand flow regulator.
36. Connect the tubing from the regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for the appropriate time shown in the table below.

Table 24: IR CO_2 Sensor Calibration Times

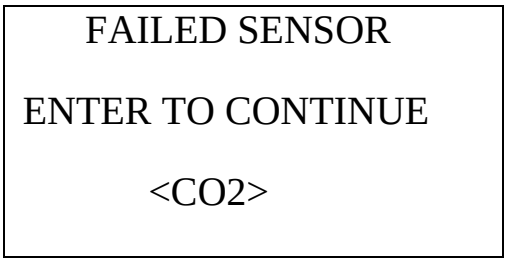
Range	Calibration Time
0-5.00 %vol	1 minute
0-10,000 ppm	90 seconds
0-60.0 %vol	90 seconds

37. Press and release the POWER ENTER RESET button to set the span adjustment for the infrared CO_2 channel to the programmed value.

38. If the infrared CO_2 channel passed calibration, the following screen sequence occurs.



If the infrared CO_2 channel cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and indicates that the infrared CO_2 sensor failed to calibrate.



The buzzer and alarm LEDs activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and continue to the Calibration Mode Screen. Attempt to calibrate the infrared CO_2 channel again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

39. Disconnect the tubing from the probe.
40. Unscrew the demand flow regulator from the calibration cylinder.
41. Use the RANGE ▼SHIFT button to place the cursor next to the **NORMAL OPERATION** menu option, then press and release the POWER ENTER RESET button to return to Measuring Mode.

Maintenance

This section includes a procedure for replacing an infrared CO_2 sensor.

Replacing the IR CO_2 Sensor or Changing Sensor Type

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main PCB with the cable that connects the top case to the main PCB.
5. Lay the top case down next to the bottom case to allow access to the flow system.
6. Locate the infrared CO_2 sensor. It has a twelve wire cable with a connector that mates to an infrared sub PCB that is installed on the main PCB and is normally located next to the pump. Figure 38 on page 202 shows an infrared CO_2 sensor in a typical location.
7. Unscrew and remove the two screws that hold down the infrared CO_2 sensor bracket.
8. Grasp the sensor firmly and pull it out of the infrared CO_2 flow chamber. Rock it back and forth gently if necessary to pull it out. Take care not to pull the cable from the sub PCB.
9. Rotate the locking lever counterclockwise on the cable connector that mates to the infrared CO_2 sensor to unlock it.
10. Unplug the old infrared CO_2 sensor from the cable.
11. Connect the new infrared CO_2 sensor to the sensor cable and rotate the locking lever clockwise to lock the connector.
12. Insert the sensor into the infrared CO_2 flow chamber and push it in until it bottoms out.
13. Line up the holes in the infrared CO_2 sensor bracket with the two standoffs on the infrared CO_2 chamber.
14. Install the two sensor bracket screws.
15. Confirm that the main PCB is seated in its slots and that its bottom edge

is resting on the bottom of the bottom case. If the main PCB is not seated properly, it may be damaged when the top case is re-installed.

16. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
17. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.
18. Calibrate the infrared CO_2 channel as described in “Infrared CO_2 Calibration” on page 204.

Parts List

Table 25: Infrared CO_2 EAGLE 2 Parts List

Part Number	Description
47-5051RK	Infrared CO_2 sensor cable
DEM-3313-1	Infrared CO_2 sensor, 0-5 %vol
DEM-3313-4	Infrared CO_2 sensor, 0-10,000 ppm
DEM-3313-5	Infrared CO_2 sensor, 0-60 %vol
81-0071RK-01	Calibration cylinder, 5000 ppm CO_2 in nitrogen, 34 liter
81-0071RK-03	Calibration cylinder, 5000 ppm CO_2 in nitrogen, 103 liter
81-0072RK-01	Calibration cylinder, 2.5 %vol CO_2 in nitrogen, 34 liter
81-0072RK-03	Calibration cylinder, 2.5 %vol CO_2 in nitrogen, 103 liter
81-0073RK-01	Calibration cylinder, 15 %vol CO_2 in nitrogen, 34 liter
81-0073RK-03	Calibration cylinder, 15 %vol CO_2 in nitrogen, 103 liter

Appendix H: Infrared Methane Sensor

Overview

This appendix describes the EAGLE 2's infrared methane sensors and includes instructions to use an EAGLE 2 that has an infrared methane sensor installed. It also includes instructions to replace an infrared methane sensor.

Table 26: Infrared Methane Sensor Specifications, %LEL Configuration

Range	Increment	Alarm 1	Alarm 2	STEL	TWA
0-100 %LEL CH_4	1 %LEL	10 %LEL	50 %LEL	N/A	N/A

Table 27: Infrared Methane Sensor Specifications, Autoranging Configuration

Range	Increment	Alarm 1	Alarm 2	STEL	TWA
0-100 %LEL CH_4	1 %LEL	10 %LEL	50 %LEL	N/A	N/A
5.0-100.0 %vol CH_4	0.5 %vol	N/A	N/A	N/A	N/A

Target Gases

The infrared methane sensor is setup for and factory-calibrated to methane. There are gases that the sensor will still detect and respond to. There are also gases that the methane sensor will not detect or respond to. Lists of the gases falling in each of these respective categories can be found below. Consult RKI Instruments, Inc. for combustible gases not listed below.

The infrared methane sensor is known to respond to the following combustible gases:

- ethane
- hexane
- IPA
- isobutane
- MEK
- propane
- toluene

The infrared methane sensor is known to **not** or to poorly respond to the following combustible gases:

- acetylene
- hydrogen
- styrene

Description

Table 26 and Table 27 above list the available infrared methane sensor configurations. The infrared methane sensor is a smart sensor that stores the target gas.

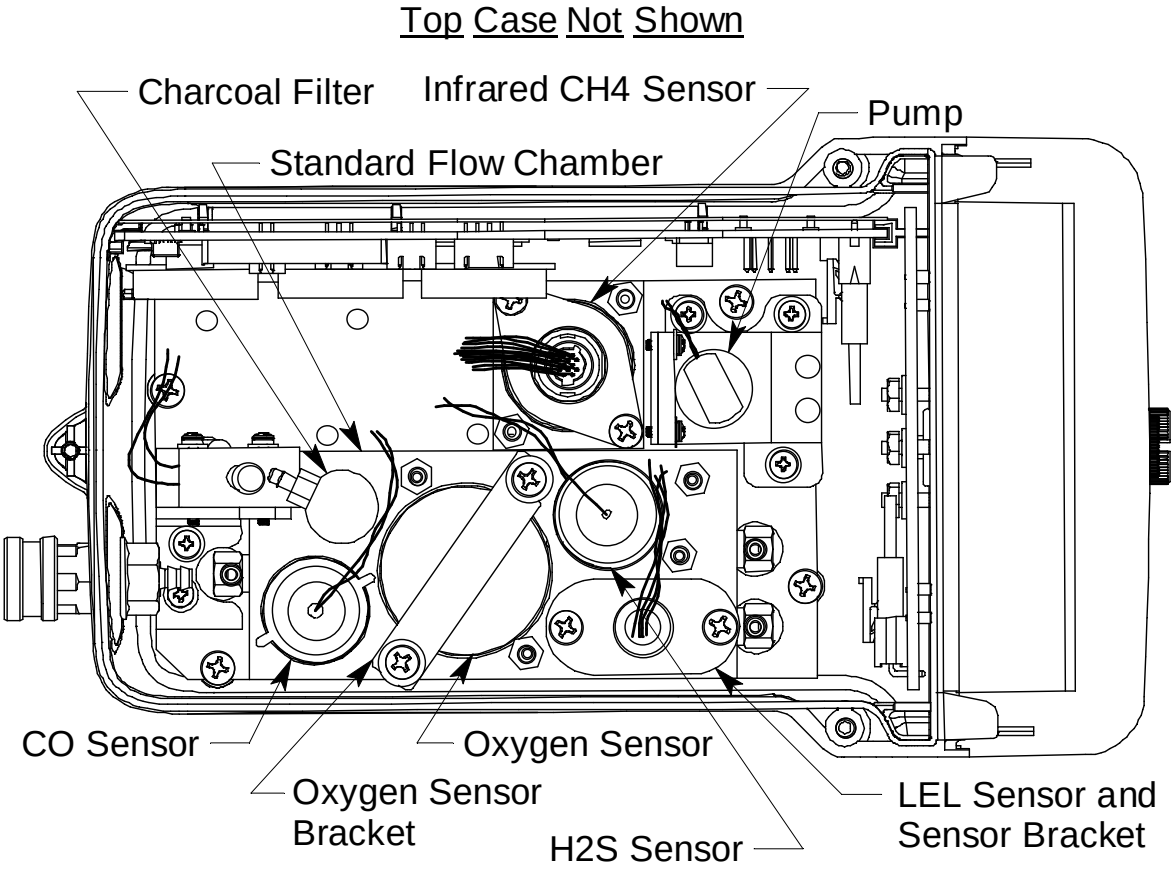


Figure 39: Typical Infrared Methane Sensor Location

The infrared methane sensor is installed in a single sensor flow chamber which is located in the area next to the standard 4-sensor flow chamber. This area can accommodate up to three single sensor flow chambers. Figure 39 above illustrates a typical infrared methane sensor location in front of the pump. The infrared methane flow chamber may also be installed in one of the other two sensor chamber locations depending on the particular version of the EAGLE 2. Some infrared methane instrument configurations do not include the 4-

sensor flow chamber.

Infrared Methane Sensor

The infrared methane sensor is a cylindrical sensor with a diffusion opening on the front and a 12 pin circular connector on the back. A 12 wire cable plugs into the back of the infrared methane sensor with a circular connector that includes a locking lever. The other end of the cable plugs into an infrared sub PCB (see description below) that is installed on the main PCB. The sensor is held in the infrared flow chamber by a bracket on standoffs.

Infrared Sub PCB

The infrared sub PCB is a circuit board that is installed on the main PCB in one of the 3 sub PCB positions when an infrared methane sensor is used with the EAGLE 2. The infrared methane sensor connects to the sub PCB with a 12-position connector. The sub PCB plugs into the main PCB and is held in place with a screw / flat washer / lock washer. There are no user serviceable parts on the infrared sub PCB.

Start Up and Normal Operation

For instructions to startup and use an EAGLE 2 that includes an infrared methane sensor, reference “Start Up” on page 22, “Measuring Mode, Normal Operation” on page 29, and “Measuring Mode, Alarms” on page 34.

0-100 %LEL/5.0-100.0 %vol Autoranging

The infrared methane sensor can be factory set to detect gas in a 0-100 %LEL configuration or an autoranging configuration. The autoranging configuration detects gas on a 0-100 %LEL and a 5.0-100.0 %vol scale. The gas reading will be displayed in %LEL until the gas level reaches 100 %LEL, or 5.0 %vol for methane. Once the gas reading is above 100 %LEL, it is displayed in %vol. Alarm points exist for the %LEL range but do not exist for the %vol range.

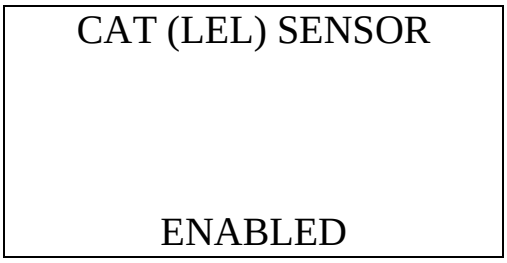
Catalytic (LEL) Sensor Screen

When either a TC sensor or an infrared combustible sensor is installed in an EAGLE 2 along with a catalytic combustible LEL sensor, the user has the option of turning off the catalytic combustible LEL sensor in Display Mode. If the unit is going to be used for sampling known high-levels of combustible gas or in areas with known catalytic sensor

poisons such as silicone vapors, the catalytic combustible sensor should be turned off. Even though this sensor has its own protective shut off, exposure to high levels of combustible gas can still stress the catalytic LEL sensor. The catalytic LEL sensor can be enabled or disabled in the Catalytic (LEL) Sensor screen in Display Mode. The default setting is enabled. To change the setting, do the following:

NOTE: The Catalytic (LEL) Sensor setting is reset when the EAGLE 2 is turned off. When the EAGLE 2 is turned on, this setting is always ENABLED.

1. Use the DISPLAY ADJUST NO button to enter Display Mode and scroll to the Catalytic (LEL) Sensor screen. The current setting will be flashing.



2. Use the AIR ▲ YES or RANGE ▼ SHIFT button to toggle to the desired setting.

   If set to DISABLED, the gas readings for the catalytic LEL channel will be replaced by dashes (---).

3. Press and release POWER ENTER RESET to save the setting and return to the main menu.
4. Use the DISPLAY ADJUST NO button to scroll through the rest of Display Mode and enter Normal Operation.

Infrared Methane Calibration

An infrared methane channel can be calibrated using the auto calibration method or the single calibration method. To calibrate an infrared methane channel using the single calibration method, see “Calibrating Using the Single Calibration Method” on page 63 and follow the instructions for calibrating a single channel. If your instrument is a multi-channel instrument that includes an infrared methane channel, RKI Instruments, Inc. recommends using the auto calibration method for convenience. The calibration instructions below show a 5 channel instrument which has the four standard channels, LEL / oxygen / H_2S / CO, and an infrared methane channel

configured for autoranging.

The standard factory calibration for the autoranging infrared methane sensor is to 50 %LEL. If your instrument is configured for autoranging and you need maximum accuracy in the %vol range, the sensor may be calibrated to
50 %vol.

To use the auto calibration method to calibrate a multi-channel instrument that includes an infrared methane channel, do the following:

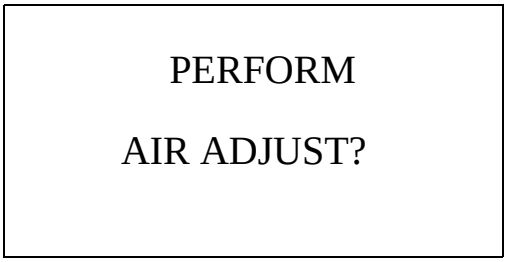
1. See “Calibration Supplies and Equipment” on page 56 for a description of the necessary calibration supplies. In addition to an appropriate multi-gas cylinder that is used to calibrate any active standard channels, you will also need a cylinder to calibrate the infrared methane channel. See Table 28 on page 227 for available cylinders. Make sure your calibration cylinder is appropriate for the infrared methane detection range.
2. Find a fresh-air environment. This is an environment free of toxic or combustible gases and of normal oxygen content (20.9%).
3. While in Measuring Mode, press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both buttons.
4. If the unit prompts you for the password, enter it by using the AIR ▲ YES and RANGE ▼ SHIFT buttons to select each password number and then pressing and releasing POWER ENTER RESET to enter the number and move on to the next one.
5. The Calibration Mode Screen displays with the cursor next to **AUTO CALIBRATION**.

```
CALIBRATION MODE

> AUTO CALIBRATION
  SINGLE CALIBRATION
  PERFORM AIR ADJUST
  NORMAL OPERATION
```

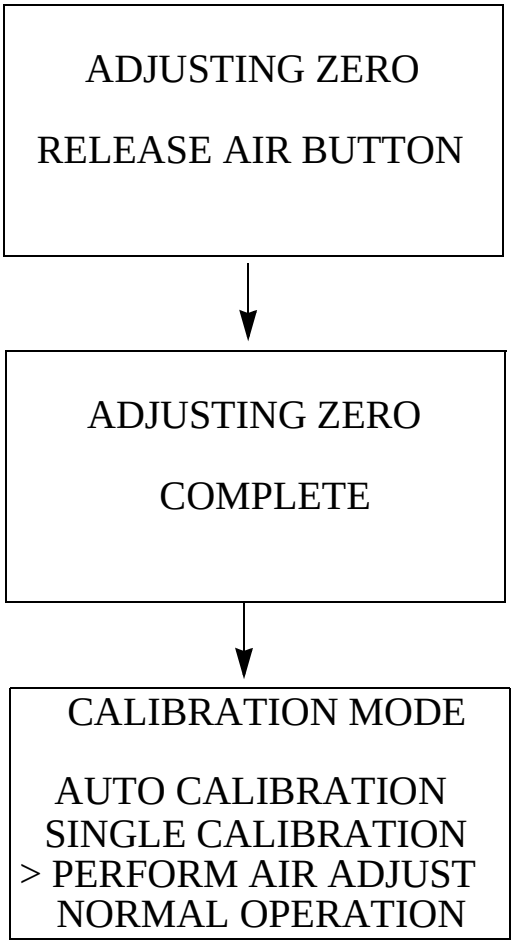
6. Move the cursor to the **PERFORM AIR ADJUST** menu item by using the RANGE ▼ SHIFT button.

```
CALIBRATION MODE

  AUTO CALIBRATION
  SINGLE CALIBRATION
> PERFORM AIR ADJUST
  NORMAL OPERATION
```

7. Press and release the POWER ENTER RESET button. The following screen appears.



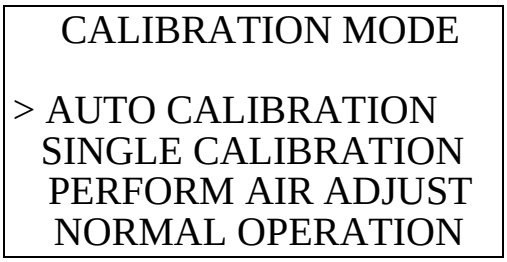
8. Press and release the AIR ▲ YES button to continue.
   If you do not want to continue, press the DISPLAY ADJUST NO button and the unit will return to the Calibration Mode Screen.
9. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.



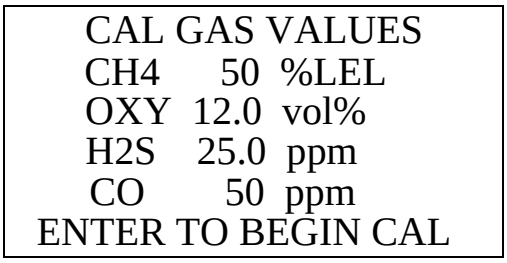
10. Install the demand flow regulator onto the multi-gas calibration cylinder.
11. Connect the sample tubing to the demand flow regulator.
12. Install the probe on the EAGLE 2 inlet fitting. Make sure the probe is complete with internal O-ring and membrane and that the two halves of

the probe are tightened firmly together to avoid leaks that can affect the calibration. See Figure 20, “Replacing the Hydrophobic Filter Disk & O-ring” on page 73 for an illustration of the internal parts of the probe.

13. Move the cursor next to the **AUTO CALIBRATION** menu item by using the AIR ▲ YES button.



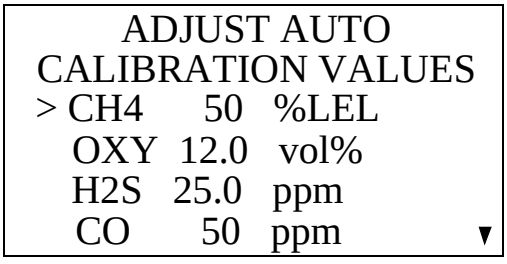
14. Press and release the POWER ENTER RESET button to display the Calibration Gas Values Screen.



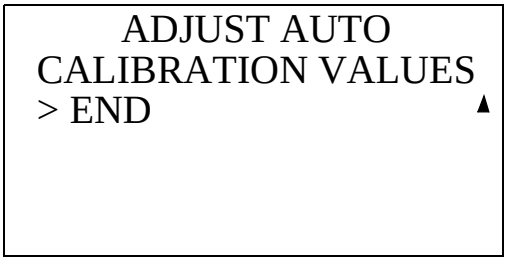
The gas concentrations displayed in the Calibration Gas Values Screen must match the gas concentrations listed on the 4-gas calibration cylinder.
If *all* concentrations match, go to Step 25.
If *one or more* concentrations *do not* match, continue with Step 15.
If you do not want to continue with the calibration, press and release the DISPLAY ADJUST NO button to return to the Calibration Mode Screen.

NOTE: The RKI 4-gas cylinder typically contains 12% O_2 by volume. When using the auto calibration method, be sure to set the “OXY” auto calibration value to agree with the concentration listed on the cylinder’s label, not zero.

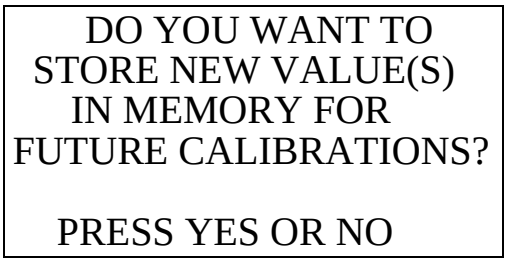
15. To adjust the values on the screen, press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both. The following screen appears with the cursor next to **CH4**.



16. Place the cursor next to the channel whose gas value you want to change using the AIR ▲ YES and RANGE ▼ SHIFT buttons.
17. Press and release the POWER ENTER RESET button to select the channel. The calibration gas value begins to flash.
18. Use the AIR ▲ YES and RANGE ▼ SHIFT buttons to adjust the calibration gas setting to the desired value.
19. Press and release the POWER ENTER RESET button to save the change. The calibration gas value stops flashing.
20. Repeat Step 16 through Step 19 for any other channels that need to be changed.
21. When you are done adjusting the calibration gas values, move the cursor down past the bottom of the screen next to **END**.



22. Press and release the POWER ENTER RESET button. The following screen appears.



23. If you select YES by pressing and releasing the AIR ▲ YES button, the changes that you made will be saved in the EAGLE 2's memory as the new auto calibration gas values.

    If you select NO by pressing and releasing the DISPLAY ADJUST NO button, the changes you made will be used for any calibrations performed during the current operating session only. The EAGLE 2 will delete the changes when the unit is turned off and will load the previous set of auto calibration values when it is turned on again.

24. When you make your selection and press the desired button, the unit returns to the Calibration Gas Values Screen.

CAL GAS VALUES
CH4 50 %LEL
OXY 12.0 vol%
H2S 25.0 ppm
CO 50 ppm
ENTER TO BEGIN CAL

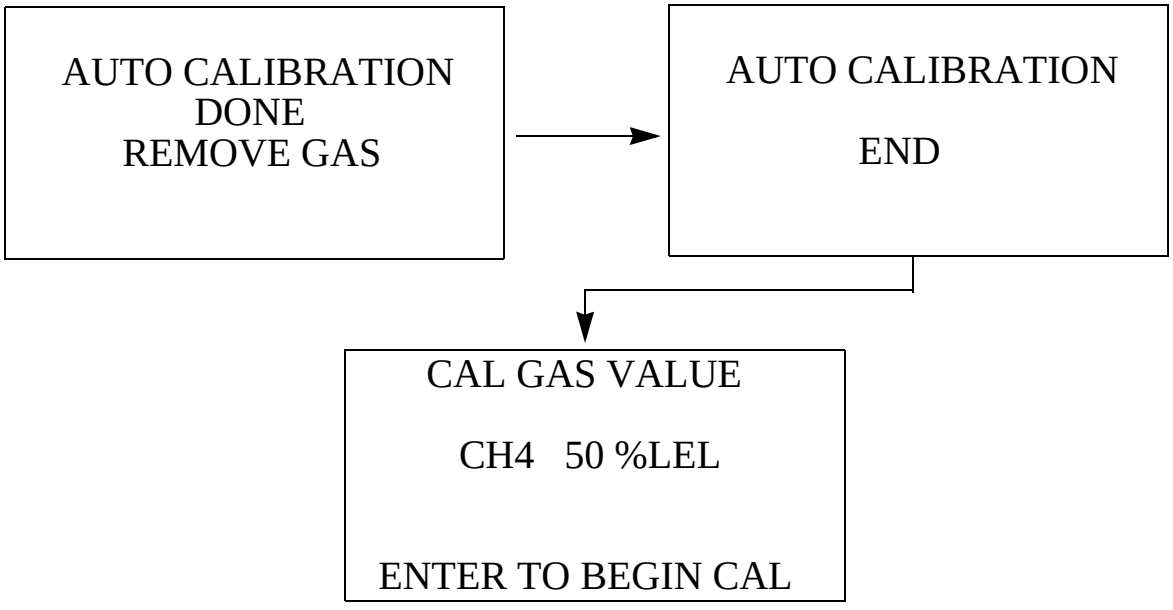
25. Press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen with **CAL IN PROCESS** flashing.

CAL IN PROCESS
CH4 0 %LEL
OXY 20.9 vol%
H2S 0.0 ppm
CO 0 ppm
ENTER WHEN DONE

If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the Cal Gas Values Screen.

If you do want to continue with the calibration, proceed to the next step.

26. Connect the tubing from the demand flow regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for one minute.
27. Press and release the POWER ENTER RESET button to set the span adjustment for each channel to the programmed values.
28. If all channels passed calibration, the following screen sequence occurs.



If any of the sensors cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and lists the sensor(s) that failed to calibrate. In the example below, the oxygen and H_2S channels failed calibration. The other sensors calibrated normally.

```
FAIL SENSOR

<  >  <OXY>
<H2S>  <  >

ENTER TO CONTINUE
```

The buzzer and alarm LEDs activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and continue to the Calibration Value Screen for the infrared methane channel. After calibrating the infrared methane channel by following the instructions below, attempt to calibrate the standard channels again. If the failure continues, investigate the cause. See "Troubleshooting" on page 68.

29. Remove the tubing from the rigid tube on the probe.
30. Unscrew the 4-gas cylinder from the demand flow regulator.
31. If you want to change the infrared methane channel's calibration gas value, follow Step 15 - Step 24 above beginning with the infrared methane Calibration Gas Value Screen below instead of the standard channel Calibration Gas Value Screen.

```
CAL GAS VALUE

CH4   50 %LEL


ENTER TO BEGIN CAL
```

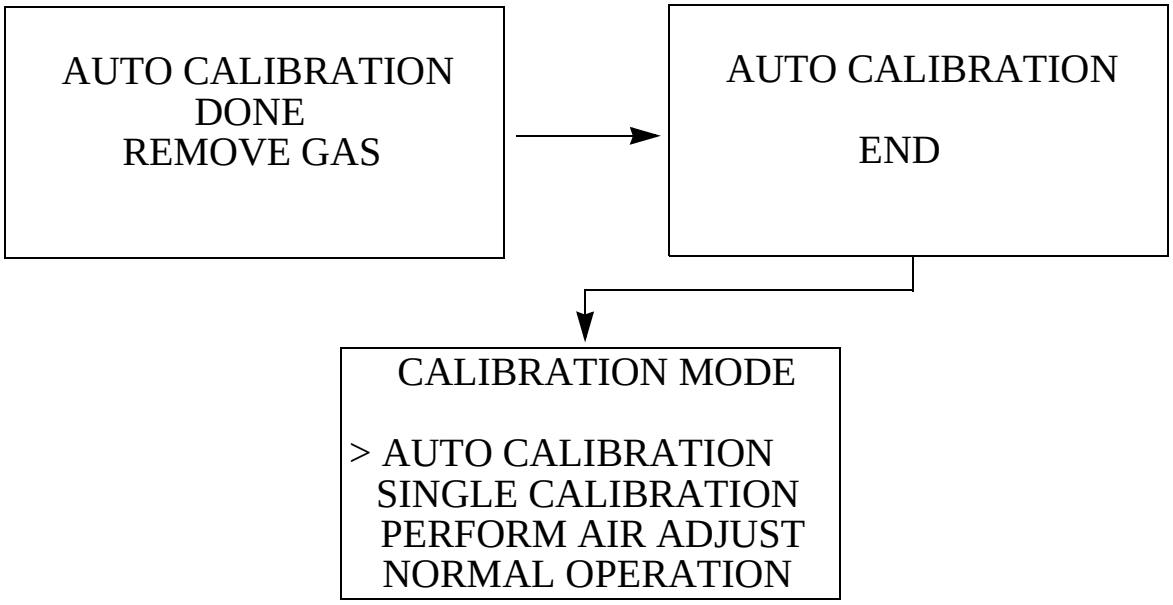
32. With the infrared methane Calibration Gas Value Screen displayed, press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen for the infrared methane channel with **CAL IN PROCESS** flashing.

```
CAL IN PROCESS

CH4    0 %LEL


ENTER WHEN DONE
```

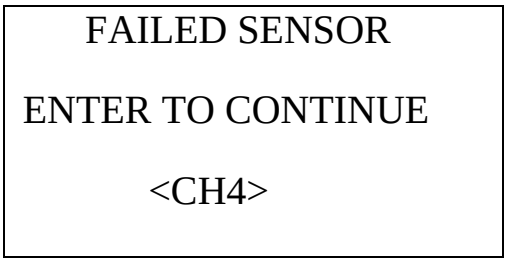
If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the infrared methane Cal Gas Values Screen.

If you do want to continue with the calibration, proceed to the next step.

33. Screw the infrared methane calibration cylinder onto the demand flow regulator.
34. Connect the tubing from the regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for 90 seconds.
35. Press and release the POWER ENTER RESET button to set the span adjustment for the infrared methane channel to the programmed value.
36. If the infrared methane channel passed calibration, the following screen sequence occurs.



If the infrared methane channel cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and indicates that the infrared methane sensor failed to calibrate.



The buzzer and alarm LEDs activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and

continue to the Calibration Mode Screen. Attempt to calibrate the infrared methane channel again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

37. Disconnect the tubing from the probe.
38. Unscrew the demand flow regulator from the calibration cylinder.
39. Use the RANGE ▼ SHIFT button to place the cursor next to the **NORMAL OPERATION** menu option, then press and release the POWER ENTER RESET button to return to Measuring Mode.

Maintenance

This section includes a procedure to replace an infrared methane sensor.

Replacing the IR Methane Sensor

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main PCB with the cable that connects the top case to the main PCB.
5. Lay the top case down next to the bottom case to allow access to the flow system.
6. Locate the infrared methane sensor. It has a twelve wire cable with a connector that mates to an infrared sub PCB that is installed on the main PCB and is normally located next to the pump. Figure 39 on page 216 shows an infrared methane sensor in a typical location.
7. Unscrew and remove the two screws that hold down the infrared methane sensor bracket.
8. Grasp the sensor firmly and pull it out of the infrared methane flow chamber. Rock it back and forth gently if necessary to pull it out. Take care not to pull the cable from the sub PCB.
9. Rotate the locking lever counterclockwise on the cable connector that mates to the infrared methane sensor to unlock it.
10. Unplug the old infrared methane sensor from the cable.
11. Connect the new infrared methane sensor to the sensor cable and rotate the locking lever clockwise to lock the connector.

12. Insert the sensor into the infrared methane flow chamber and push it in until it bottoms out.
13. Line up the holes in the infrared methane sensor bracket with the two standoffs on the infrared methane chamber.
14. Install the two sensor bracket screws.
15. Confirm that the main PCB is seated in its slots and that its bottom edge is resting on the bottom of the bottom case. If the main PCB is not seated properly, it may be damaged when the top case is re-installed.
16. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
17. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.
18. Calibrate the infrared methane channel as described in “Infrared Methane Calibration” on page 218.

Parts List

Table 28: Infrared CH_4 EAGLE 2 Parts List

Part Number	Description
47-5051RK	Infrared CH_4 sensor cable
DEM-3313-3	Infrared CH_4 sensor, 0-100 %LEL or 0-100 %LEL/5.0-100.0 %vol autoranging
81-0012RK-01	Calibration cylinder, 50 %LEL CH_4 in air, 34 liter steel
81-0012RK-03	Calibration cylinder, 50 %LEL CH_4 in air, 103 liter steel
81-0013RK-01	Calibration cylinder, 50 %vol CH_4 in N_2, 34 liter steel
81-0013RK-05	Calibration cylinder, 50 %vol CH_4 in N_2, 58 liter steel

Appendix I: Infrared Hydrocarbon Sensor

Overview

This appendix describes the EAGLE 2's infrared hydrocarbon sensor and includes instructions to use an EAGLE 2 that has an infrared hydrocarbon sensor installed. It also includes instructions to replace an infrared hydrocarbon sensor.

Table 29: Infrared Hydrocarbon Sensor Specifications, %LEL Configuration

Range	Increment	Alarm 1	Alarm 2	STEL	TWA
0-100 %LEL IBU	1 %LEL	10 %LEL	50 %LEL	N/A	N/A

Table 30: Infrared Hydrocarbon Sensor Specifications, Autoranging Configuration

Range	Increment	Alarm 1	Alarm 2	STEL	TWA
0-100 %LEL IBU	1 %LEL	10 %LEL	50 %LEL	N/A	N/A
2.0-30.0 %vol IBU	0.5 %vol	N/A	N/A	N/A	N/A

Target Gases

The infrared HC sensor is a general hydrocarbon sensor. It is setup for and factory-calibrated to isobutane.

Description

Table 29 and Table 30 above list the available infrared hydrocarbon sensor configurations. The infrared hydrocarbon sensor is a smart sensor that stores the target gas. The infrared hydrocarbon sensor is installed in a single sensor flow chamber which is located in the area next to the standard 4-sensor flow chamber. This area can accommodate up to three single sensor flow chambers. Figure 40 above illustrates a typical infrared hydrocarbon sensor location in front of the pump. The infrared hydrocarbon flow chamber may also be installed in one of the other two sensor chamber locations depending on the particular version of the EAGLE 2. Some infrared hydrocarbon instrument configurations do not include the 4-sensor flow chamber.

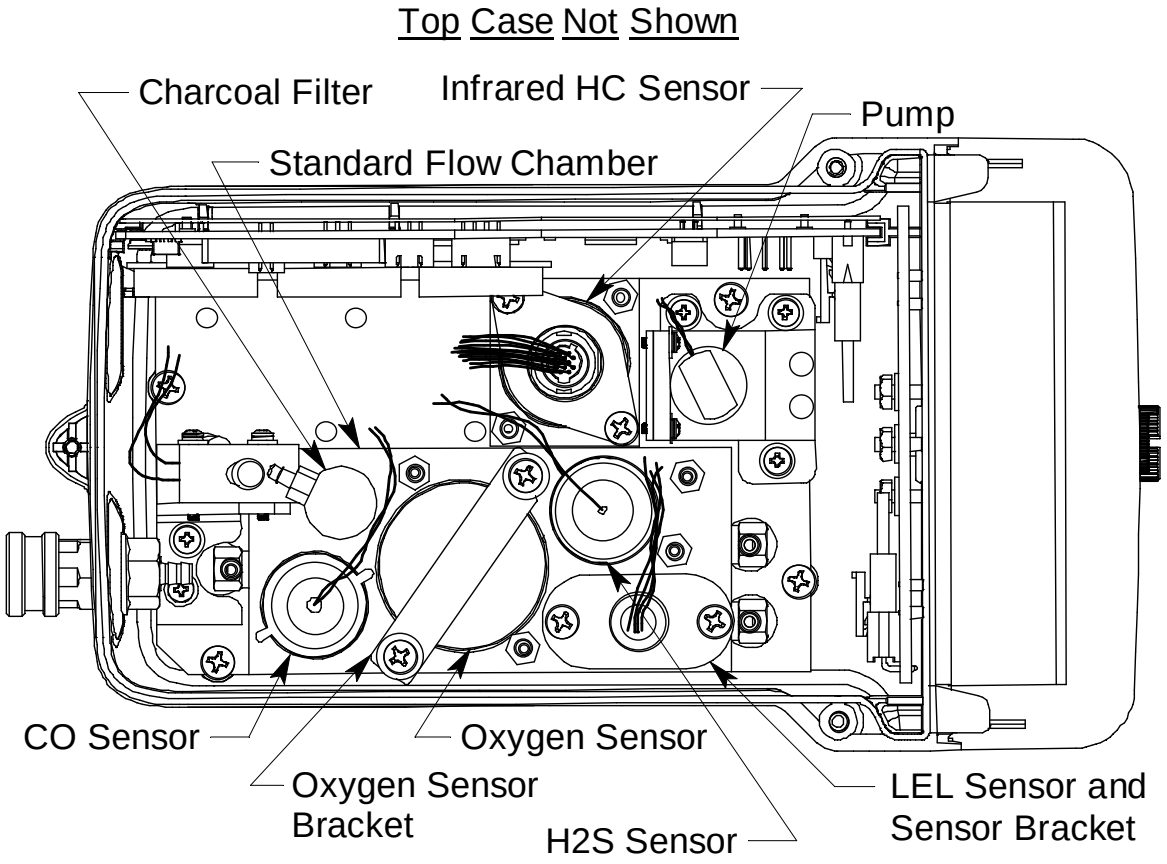


Figure 40: Typical Infrared Hydrocarbon Sensor Location

Infrared Hydrocarbon Sensor

The infrared hydrocarbon sensor is a cylindrical sensor with a diffusion opening on the front and a 12 pin circular connector on the back. A 12 wire cable plugs into the back of the infrared hydrocarbon sensor with a circular connector that includes a locking lever. The other end of the cable plugs into an infrared sub PCB (see description below) that is installed on the main PCB. The sensor is held in the infrared flow chamber by a bracket on standoffs.

Infrared Sub PCB

The infrared sub PCB is a circuit board that is installed on the main PCB in one of the 3 sub PCB positions when an infrared hydrocarbon sensor is used with the EAGLE 2. The infrared hydrocarbon sensor connects to the sub PCB with a 12-position connector. The sub PCB plugs into the main PCB and is held in place with a screw / flat washer / lock washer. There are no user serviceable parts on the infrared sub PCB.

Start Up and Normal Operation

For instructions to startup and use an EAGLE 2 that includes an infrared hydrocarbon sensor, reference “Start Up” on page 22, “Measuring Mode, Normal Operation” on page 29, and “Measuring Mode, Alarms” on page 34.

0-100 %LEL/5.0-100.0 %vol Autoranging

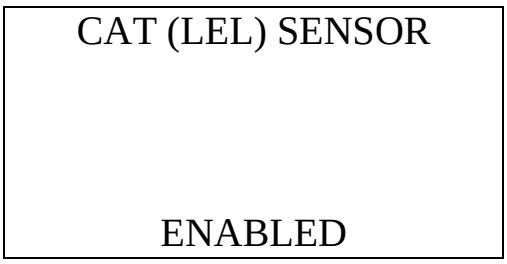
The infrared hydrocarbon sensor can be factory set to detect gas in a 0-100 %LEL configuration or an autoranging configuration. The autoranging configuration detects gas on a 0-100 %LEL and a 2.0-30.0 %vol scale. The gas reading will be displayed in %LEL until the gas level reaches 100 %LEL, or 2.0 %vol for isobutane. Once the gas reading is above 100 %LEL, it is displayed in %vol. Alarm points exist for the %LEL range but do not exist for the %vol range.

Catalytic (LEL) Sensor Screen

When either a TC sensor or an infrared combustible sensor is installed in an EAGLE 2 along with a catalytic combustible LEL sensor, the user has the option of turning off the catalytic combustible LEL sensor in Display Mode. If the unit is going to be used for sampling known high-levels of combustible gas or in areas with known catalytic sensor poisons such as silicone vapors, the catalytic combustible sensor should be turned off. Even though this sensor has its own protective shut off, exposure to high levels of combustible gas can still stress the catalytic LEL sensor. The catalytic LEL sensor can be enabled or disabled in the Catalytic (LEL) Sensor screen in Display Mode. The default setting is enabled. To change the setting, do the following:

NOTE: The Catalytic (LEL) Sensor setting is reset when the EAGLE 2 is turned off. When the EAGLE 2 is turned on, this setting is always ENABLED.

1. Use the DISPLAY ADJUST NO button to enter Display Mode and scroll to the Catalytic (LEL) Sensor screen. The current setting will be flashing.



2. Use the AIR ▲ YES or RANGE ▼ SHIFT button to toggle to the desired setting.

   If set to DISABLED, the gas reading for the catalytic LEL channel will be replaced by dashes (---).

3. Press and release POWER ENTER RESET to save the setting and return to the main menu.
4. Use the DISPLAY ADJUST NO button to scroll through the rest of Display Mode and enter Normal Operation.

Infrared Hydrocarbon Calibration

An infrared hydrocarbon channel can be calibrated using the auto calibration method or the single calibration method. To calibrate an infrared hydrocarbon channel using the single calibration method, see “Calibrating Using the Single Calibration Method” on page 63 and follow the instructions for calibrating a single channel. If your instrument is a multi-channel instrument that includes an infrared hydrocarbon channel, RKI Instruments, Inc. recommends using the auto calibration method for convenience. The calibration instructions below show a 5 channel instrument which has the four standard channels, LEL / oxygen / H_2S / CO, and an infrared hydrocarbon channel.

The standard factory calibration for the autoranging infrared hydrocarbon sensor is to 50 %LEL isobutane. If you need maximum accuracy in the %vol range, the sensor may be calibrated to 50 %vol isobutane.

To use the auto calibration method to calibrate a multi-channel instrument that includes an infrared hydrocarbon channel, do the following:

1. See “Calibration Supplies and Equipment” on page 56 for a description of the necessary calibration supplies. In addition to an appropriate multi-gas cylinder that is used to calibrate any active standard channels, you will also need a cylinder to calibrate the infrared hydrocarbon channel. See Table 31 on page 240 for available cylinders. Make sure your calibration cylinder is appropriate for the infrared hydrocarbon detection range.
2. Find a fresh-air environment. This is an environment free of toxic or combustible gases and of normal oxygen content (20.9%).
3. While in Measuring Mode, press and hold the RANGE ▼ SHIFT button,

then press the DISPLAY ADJUST NO button and release both buttons.

4. If the unit prompts you for the password, enter it by using the AIR ▲ YES and RANGE ▼SHIFT buttons to select each password number and then pressing and releasing POWER ENTER RESET to enter the number and move on to the next one.
5. The Calibration Mode Screen displays with the cursor next to **AUTO CALIBRATION**.

```
CALIBRATION MODE

> AUTO CALIBRATION
  SINGLE CALIBRATION
  PERFORM AIR ADJUST
  NORMAL OPERATION
```

6. Move the cursor to the **PERFORM AIR ADJUST** menu item by using the RANGE ▼SHIFT button.

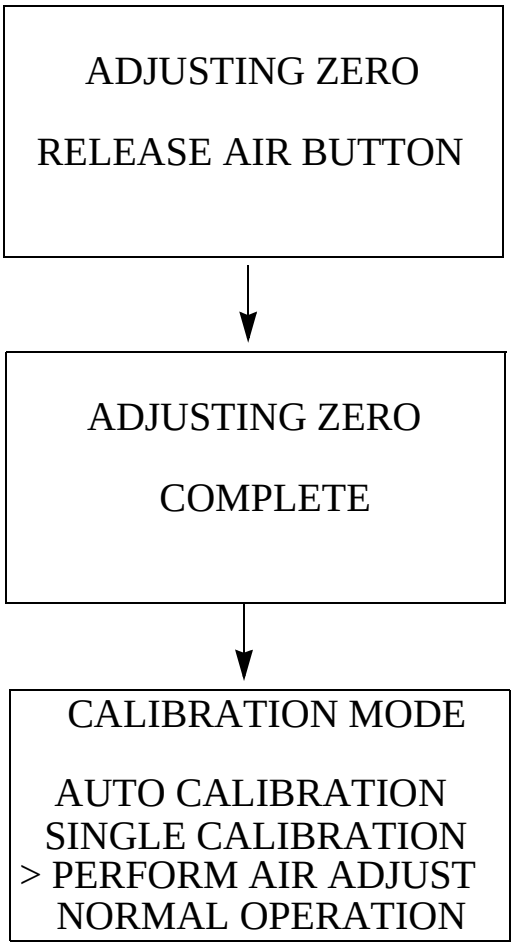
```
CALIBRATION MODE

  AUTO CALIBRATION
  SINGLE CALIBRATION
> PERFORM AIR ADJUST
  NORMAL OPERATION
```

7. Press and release the POWER ENTER RESET button. The following screen appears.

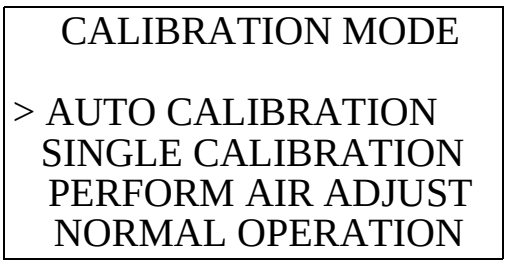
```
PERFORM

AIR ADJUST?
```

8. Press and release the AIR ▲ YES button to continue.
   If you do not want to continue, press the DISPLAY ADJUST NO button and the unit will return to the Calibration Mode Screen.

9. The EAGLE 2 will indicate that it is adjusting the zero reading for a few seconds, then indicate that the operation is complete before returning to the Calibration Mode Screen.



10. Install the demand flow regulator onto the multi-gas calibration cylinder.
11. Connect the sample tubing to the demand flow regulator.
12. Install the probe on the EAGLE 2 inlet fitting. Make sure the probe is complete with internal O-ring and membrane and that the two halves of the probe are tightened firmly together to avoid leaks that can affect the calibration. See Figure 20, “Replacing the Hydrophobic Filter Disk & O-ring” on page 73 for an illustration of the internal parts of the probe.
13. Move the cursor next to the **AUTO CALIBRATION** menu item by using the AIR ▲ YES button.



14. Press and release the POWER ENTER RESET button to display the Calibration Gas Values Screen.

```
CAL GAS VALUES
CH4     50  %LEL
OXY   12.0  vol%
H2S   25.0  ppm
CO      50  ppm
ENTER TO BEGIN CAL
```

The gas concentrations displayed in the Calibration Gas Values Screen must match the gas concentrations listed on the 4-gas calibration cylinder.
If *all* concentrations match, go to Step 25.
If *one or more* concentrations *do not* match, continue with Step 15.
If you do not want to continue with the calibration, press and release the DISPLAY ADJUST NO button to return to the Calibration Mode Screen.

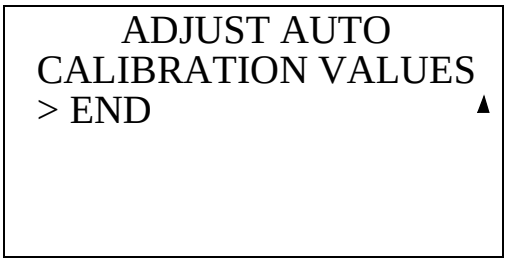
NOTE: The RKI 4-gas cylinder typically contains 12% O_2 by volume. When using the auto calibration method, be sure to set the "OXY" auto calibration value to agree with the concentration listed on the cylinder's label, not zero.

15. To adjust the values on the screen, press and hold the RANGE ▼ SHIFT button, then press the DISPLAY ADJUST NO button and release both. The following screen appears with the cursor next to **CH4**.

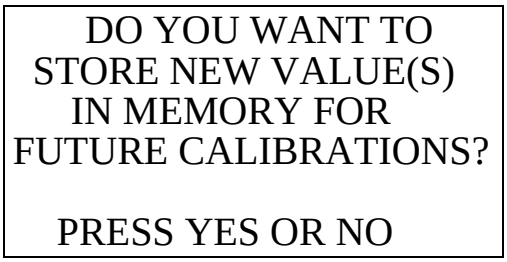
```
ADJUST AUTO
CALIBRATION VALUES
> CH4     50   %LEL
  OXY   12.0   vol%
  H2S   25.0   ppm
  CO      50   ppm      ▼
```

16. Place the cursor next to the channel whose gas value you want to change using the AIR ▲ YES and RANGE ▼ SHIFT buttons.
17. Press and release the POWER ENTER RESET button to select the channel. The calibration gas value begins to flash.
18. Use the AIR ▲ YES and RANGE ▼ SHIFT buttons to adjust the calibration gas setting to the desired value.
19. Press and release the POWER ENTER RESET button to save the change. The calibration gas value stops flashing.
20. Repeat Step 16 through Step 19 for any other channels that need to be changed.

21. When you are done adjusting the calibration gas values, move the cursor down past the bottom of the screen next to **END**.



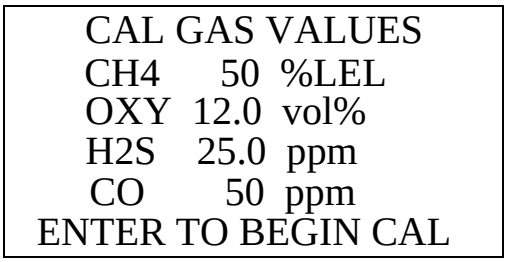
22. Press and release the POWER ENTER RESET button. The following screen appears.



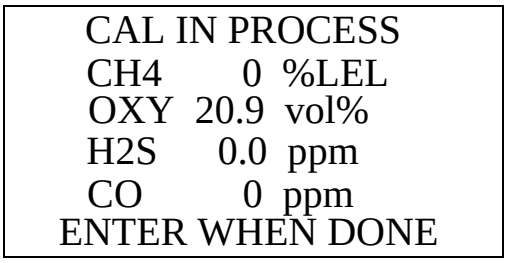
23. If you select YES by pressing and releasing the AIR ▲ YES button, the changes that you made will be saved in the EAGLE 2's memory as the new auto calibration gas values.

    If you select NO by pressing and releasing the DISPLAY ADJUST NO button, the changes you made will be used for any calibrations performed during the current operating session only. The EAGLE 2 will delete the changes when the unit is turned off and will load the previous set of auto calibration values when it is turned on again.

24. When you make your selection and press the desired button, the unit returns to the Calibration Gas Values Screen.



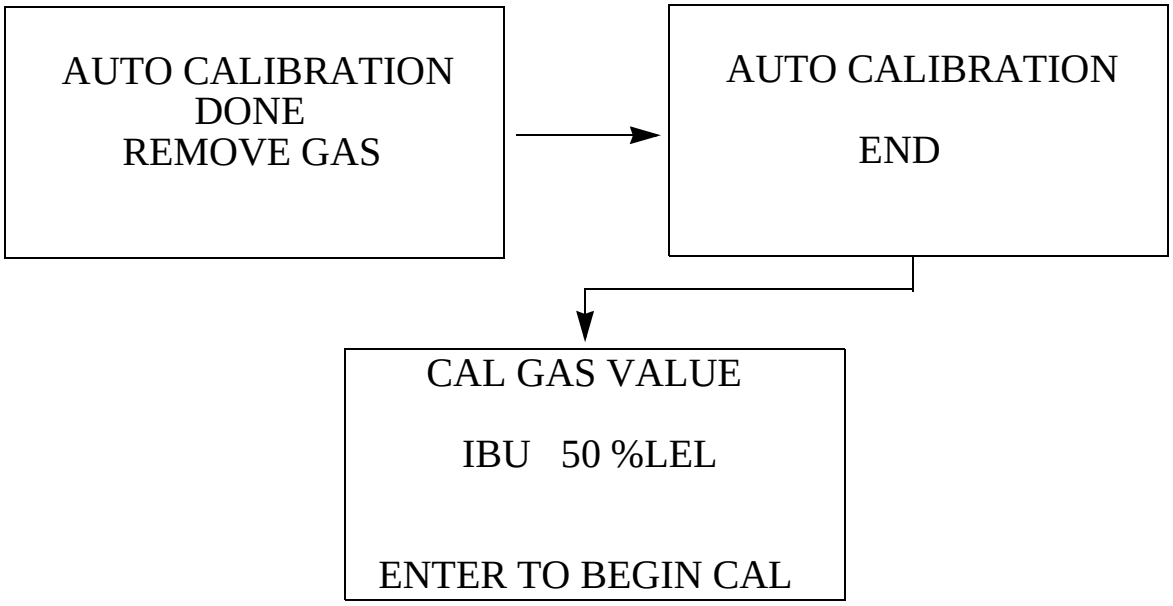
25. Press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen with **CAL IN PROCESS** flashing.



If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the Cal Gas Values Screen.

If you do want to continue with the calibration, proceed to the next step.

26. Connect the tubing from the demand flow regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for one minute.
27. Press and release the POWER ENTER RESET button to set the span adjustment for each channel to the programmed values.
28. If all channels passed calibration, the following screen sequence occurs.



If any of the sensors cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and lists the sensor(s) that failed to calibrate. In the example below, the oxygen and H_2S channels failed calibration. The other sensors calibrated normally.

```
FAIL SENSOR

<  >  <OXY>
<H2S>  <  >

ENTER TO CONTINUE
```

The buzzer and alarm LEDs activate in a double pulsing pattern. Press and release the POWER ENTER RESET button to reset the alarm and continue to the Calibration Value Screen for the infrared hydrocarbon channel. After calibrating the infrared hydrocarbon channel by following the instructions below, attempt to calibrate the standard channels again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

29. Remove the tubing from the rigid tube on the probe.
30. Unscrew the 4-gas cylinder from the demand flow regulator.
31. If you want to change the infrared hydrocarbon channel’s calibration gas value, follow Step 15 - Step 24 above beginning with the infrared hydrocarbon Calibration Gas Value Screen below instead of the standard channel Calibration Gas Value Screen.

```
CAL GAS VALUE

IBU   50 %LEL


ENTER TO BEGIN CAL
```

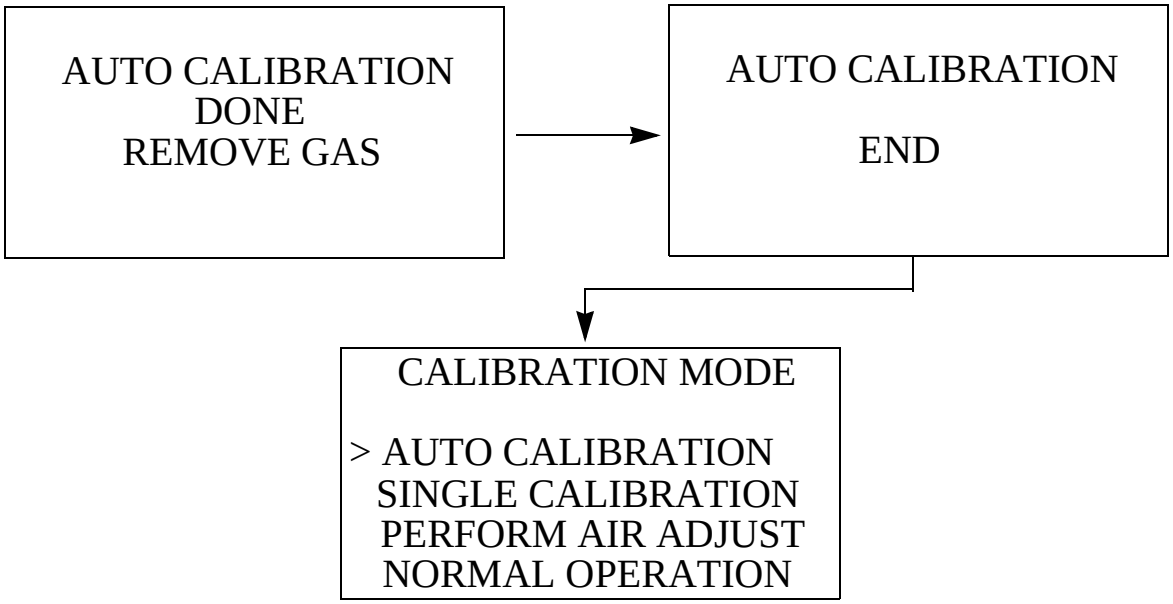
32. With the infrared hydrocarbon Calibration Gas Value Screen displayed, press and release the POWER ENTER RESET button to proceed to the Calibration In Process Screen for the infrared hydrocarbon channel with **CAL IN PROCESS** flashing.

```
CAL IN PROCESS

IBU    0 %LEL


ENTER WHEN DONE
```

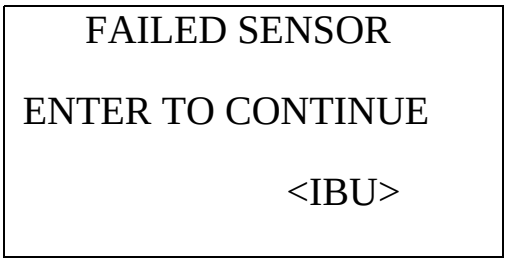
If you do not want to proceed with the calibration, press and release the DISPLAY ADJUST NO button to return to the infrared hydrocarbon Cal Gas Values Screen.

If you do want to continue with the calibration, proceed to the next step.

33. Screw the infrared hydrocarbon calibration cylinder onto the demand flow regulator.
34. Connect the tubing from the regulator to the rigid tube on the probe. Allow the EAGLE 2 to draw gas for one minute.
35. Press and release the POWER ENTER RESET button to set the span adjustment for the infrared hydrocarbon channel to the programmed value.
36. If the infrared hydrocarbon channel passed calibration, the following screen sequence occurs.



If the infrared hydrocarbon channel cannot be adjusted to the proper value, a screen displays that indicates a calibration failure and indicates that the infrared hydrocarbon sensor failed to calibrate.



The buzzer and alarm LEDs activate in a double pulsing pattern. Press

and release the POWER ENTER RESET button to reset the alarm and continue to the Calibration Mode Screen. Attempt to calibrate the infrared hydrocarbon channel again. If the failure continues, investigate the cause. See “Troubleshooting” on page 68

37. Disconnect the tubing from the probe.
38. Unscrew the demand flow regulator from the calibration cylinder.
39. Use the RANGE ▼SHIFT button to place the cursor next to the **NORMAL OPERATION** menu option, then press and release the POWER ENTER RESET button to return to Measuring Mode.

Maintenance

This section includes a procedure to replace an infrared hydrocarbon sensor.

Replacing the IR Hydrocarbon Sensor

1. Verify that the EAGLE 2 is off.
2. Place the EAGLE 2 upside down on a flat surface or hold it upside down.
3. Unscrew the three case screws until they disengage from the top case. They are captive screws so they will not fall off of the bottom case.
4. Turn the EAGLE 2 right side up and carefully lift the top case away from the bottom case. Be careful not to lift it so far that it pulls on the main PCB with the cable that connects the top case to the main PCB.
5. Lay the top case down next to the bottom case to allow access to the flow system.
6. Locate the infrared hydrocarbon sensor. It has a twelve wire cable with a connector that mates to an infrared sub PCB that is installed on the main PCB and is normally located next to the pump. Figure 40 on page 229 shows an infrared hydrocarbon sensor in a typical location.
7. Unscrew and remove the two screws that hold down the infrared hydrocarbon sensor bracket.
8. Grasp the sensor firmly and pull it out of the infrared hydrocarbon flow chamber. Rock it back and forth gently if necessary to pull it out. Take care not to pull the cable from the sub PCB.
9. Rotate the locking lever counterclockwise on the cable connector that mates to the infrared hydrocarbon sensor to unlock it.
10. Unplug the old infrared hydrocarbon sensor from the cable.
11. Connect the new infrared hydrocarbon sensor to the sensor cable and

rotate the locking lever clockwise to lock the connector.

12. Insert the sensor into the infrared hydrocarbon flow chamber and push it in until it bottoms out.
13. Line up the holes in the infrared hydrocarbon sensor bracket with the two standoffs on the infrared hydrocarbon chamber.
14. Install the two sensor bracket screws.
15. Confirm that the main PCB is seated in its slots and that its bottom edge is resting on the bottom of the bottom case. If the main PCB is not seated properly, it may be damaged when the top case is re-installed.
16. Make sure that the top case gasket is fully seated in its groove and carefully put the top case back on the bottom case. If you have any difficulty mating the top and bottom cases, inspect the placement of the main PCB and the placement of the top case gasket.
17. Turn the EAGLE 2 upside down and tighten the three case screws to secure the top case to the bottom case.
18. Calibrate the infrared hydrocarbon channel as described in “Infrared Hydrocarbon Calibration” on page 231.

Parts List

Table 31: Infrared HC EAGLE 2 Parts List

Part Number	Description
47-5051RK	Infrared HC sensor cable
DEM-3313-2	Infrared HC sensor, 0-100 %LEL/5.0-100.0 %vol autoranging
81-0018RK-01	Calibration cylinder, 50 %LEL isobutane in air, 34 liter steel
81-0018RK-03	Calibration cylinder, 50 %LEL isobutane in air, 103 liter steel

Appendix J: Methane Elimination Mode

Overview

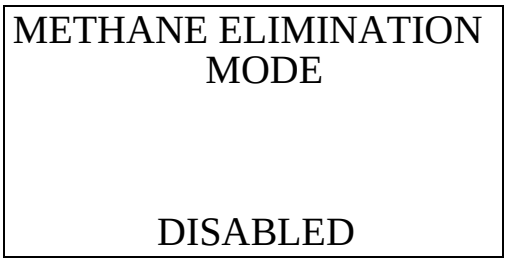
For applications where methane is an interfering gas, you can set the EAGLE 2 to eliminate most response to methane using methane elimination mode.

CAUTION: *The EAGLE 2 catalytic combustible sensor experiences a significant gas response drop when it is changed from full response mode to methane elimination mode. The EAGLE 2 must be calibrated in both full response mode and in methane elmination mode to account for this. See "Calibration" on page 244 for further instructions.*

Monitoring in Methane Elimination Mode

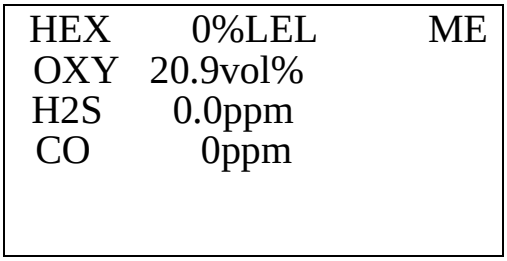
To monitor an area using methane elimination mode, do the following:

1. Turn on the EAGLE 2 as described in "Start Up" on page 22.
2. Make sure that the EAGLE 2 catalytic combustible channel is set to monitor a gas in which methane elimination is an option. For a list of these gases and a procedure to select one, see "Configuring the Combustible Gas" on page 104. A common target gas is hexane. Once a gas that allows for methane elimination is selected for the catalytic combustible channel, the methane elimination mode screen becomes part of Display Mode.
3. Use the DISPLAY button to enter Display Mode and to scroll through the screens until you reach the Methane Elimination Mode screen. The current setting is displayed.



4. Press and release the AIR ▲ YES or RANGE ▼ SHIFT button to toggle the setting to ENABLED.

5. Press and release the POWER ENTER RESET button. The unit will save the setting and proceed to the next menu item.
6. You will note that if methane elimination is enabled, the Catalytic Sensor Relative Response screen no longer appears even if the relative response feature in Setup Mode is turned on. While methane elimination is enabled, the Catalytic Sensor Relative Response screen will not appear in Display Mode even if the relative response feature in Setup Mode is enabled.
7. Continue to press the DISPLAY button until the Measuring Mode screen appears.



When the instrument is reading in methane elimination, an ME appears in line with the catalytic combustible channel reading.

8. Allow 2 minutes for the combustible sensor to stabilize.
9. Perform a demand zero. See “Performing a Demand Zero” on page 27 for instructions.
10. Monitor for the target gas.
11. If you wish to monitor for any other gas while in methane elimination mode, a conversion factor must be taken into consideration. With the EAGLE 2 calibrated to hexane, use Table 32 below to determine the concentrations of other target gases. Multiply the display reading by the factor in the appropriate column to determine the actual reading for that gas. For example, if you are using the EAGLE 2 in methane elimination mode to detect isobutane and the display reads 10% LEL, the actual isobutane reading is 10% x 0.59 = 5.9% LEL isobutane.

Table 32: Methane Elimination Mode Conversion Factors (Hexane Calibration)

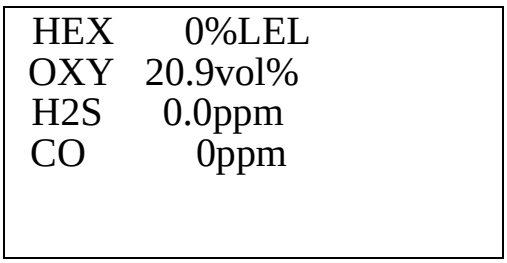
Target Gas	LEL Factor	PPM Factor
Acetone	0.58	1.32
Benzene	1.01	1.10
Butyl Acrylate	*	1.52
Butyl Acetate	1.34	1.58

Target Gas	LEL Factor	PPM Factor
Isobutane	0.59	0.97
Isopropanol	0.85	1.55
Methane	No response	No response
Methanol	0.58	3.16

Target Gas	LEL Factor	PPM Factor	Target Gas	LEL Factor	PPM Factor
2-Butyl Alcohol	0.84	1.30	Methyl Acetate	0.55	1.55
1-Butyl Alcohol	1.71	2.18	Methyl Acrylate	0.83	2.11
Cyclohexane	1.06	1.25	Methyl Ethyl Keytone	1.04	1.32
Cumene	1.74	1.42	Methyl Isobutyl Keytone	1.30	1.42
Ethylene Dichloride	2.04	11.50	Mixed Xylenes	1.36	1.36
Ethyl Alcohol	0.57	1.71	Nonane	1.66	1.21
Ethyl Chloride	0.59	2.04	Pentane	0.54	0.74
Ethyl Acrylate	1.32	1.68	Propane	Low response	Low response
Hexane	1.00	1.00	Styrene	1.74	1.42
Hydrogen	0.48	1.75	Toluene	1.25	1.25
			Vinyl Acetate Monomer	0.92	2.17
* Vapor pressure too low for significant LEL reading					

WARNING: ***The EAGLE 2's alarms are initiated by the display reading, not the factored reading. If you are monitoring for isobutane as in the above example and the low alarm is set for 10% LEL, the EAGLE 2 will initiate a low alarm at 5.9% LEL isobutane (display reading of 10% LEL).***

12. To return to full response mode, return to the Methane Elimination Mode screen in Display Mode and press and release the AIR ▲ YES or RANGE ▼ SHIFT button to toggle the setting to DISABLED.
13. Press and release the POWER ENTER RESET button. The unit will save the setting and proceed to the next menu item.
14. Continue to press the DISPLAY button until the Measuring Mode screen appears.



The ME is no longer next to the catalytic combustible channel reading indicating that the unit is measuring in full response mode.

15. Allow 2 minutes for the combustible sensor to stabilize before monitoring the target gas.
16. Perform a demand zero. See “Performing a Demand Zero” on page 27 for instructions.
17. Monitor for the target gas.

NOTE: The EAGLE 2 retains the methane elimination mode setting when it is turned off. The methane elimination mode setting, ENABLED or DISABLED, will remain in effect until it is changed in Display Mode. So if methane elimination mode is enabled when you turn off the EAGLE 2, it will remain enabled when you turn the EAGLE 2 on again.

Calibration

The EAGLE 2 stores calibration data for the instrument both in methane elimination mode and in full response mode. When using the instrument for applications where methane elimination mode is used, it is most common to calibrate to hexane. If you are planning to use the EAGLE 2 in methane elimination mode, RKI Instruments, Inc. recommends that you setup and calibrate the instrument to hexane in both full response and methane elimination mode unless your application requires a different setup and calibration. See “Configuring the Combustible Gas” on page 104 for instructions to setup the catalytic combustible channel gas.

CAUTION: *The EAGLE 2 catalytic combustible sensor experiences a significant gas response drop when it is changed from full response mode to methane elimination mode. The EAGLE 2 must be calibrated in both full response mode and in methane elmination mode to account for this.*

To properly calibrate the instrument, do the following:

1. With the EAGLE 2 catalytic combustible channel set up for hexane, perform a demand zero and a calibration while in full response. See “Chapter 4: Calibration Mode” on page 55 for instructions.
2. Enable methane elimination in Display Mode.
3. Allow the unit to stabilize for 2 minutes.

4. Perform a demand zero and a calibration while in methane elimination mode. See “Chapter 4: Calibration Mode” on page 55 for instructions.

Appendix K: Using the EAGLE 2 in Bar Hole Mode

Overview

This chapter explains how to operate the EAGLE 2 in Bar Hole Mode. Bar Hole Mode is used to perform consistent checks of bar holes when tracking down underground gas leaks. When the EAGLE 2 is in Bar Hole Mode, only the combustible and oxygen sensors are displayed.

If an EAGLE 2 is intended for bar hole testing, it is shipped with Bar Hole Mode or both Bar Hole Mode and Leak Check Mode enabled so that the operator must choose which operational mode to use when the unit is turned on (see "Updating LC/BH Mode Setting" on page 120).

Start Up, Bar Hole Mode

This section explains how to start up the EAGLE 2 in Bar Hole Mode and get it ready for operation.

Turning On the EAGLE 2, Bar Hole Mode

WARNING: If one or more sensors other than a catalytic LEL, TC, or oxygen sensor is installed, these sensors will not be active while the EAGLE 2 is in Bar Hole Mode.

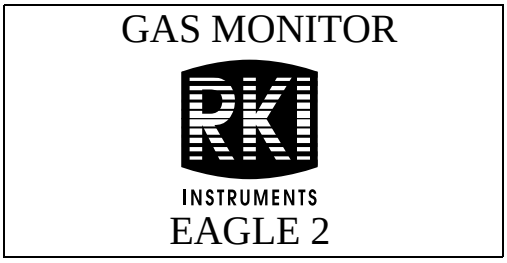
WARNING: Gas alarms are not active when the EAGLE 2 is in Bar Hole Mode.

The following description of the EAGLE 2 start up sequence assumes that the following menu items in Setup Mode are turned on: CAL REMINDER and USER/STATION ID. If either of these items is turned off, then the corresponding screen will not appear.

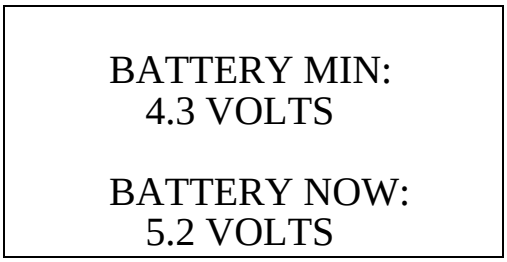
NOTE: In order for **BAR HOLE MODE** to appear as a selection in the Mode Select Screen in Step 3 below, the EAGLE 2 must have both a catalytic LEL sensor and a TC sensor installed. In addition, both the catalytic LEL and TC channels must be configured for methane, CH_4, in the CONFIGURE GASES menu item in Setup Mode. If an EAGLE 2 has only the catalytic LEL sensor installed or if the TC channel is configured for a gas other than CH_4, then **BAR HOLE MODE**

will not appear as a choice as shown in Step 3 below and **NORMAL MODE** and **LEAK CHECK MODE** will be the only choices displayed. In this case, see “Turning On the EAGLE 2” on page 22 or “Turning On the EAGLE 2, Leak Check Mode” on page 255.

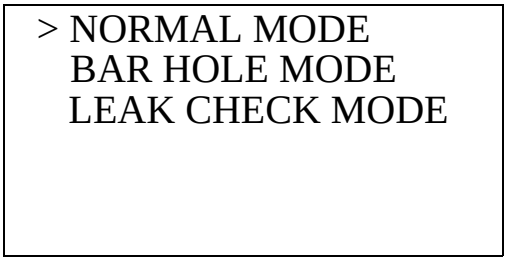
1. Connect the sample hose to the EAGLE 2’s quick connect inlet fitting.
2. Connect the bar hole probe to the sample hose’s quick connect fitting.
3. Press and briefly hold down the POWER ENTER RESET button. Release the button when you hear a beep.
4. The LCD will show the following screen for about ten seconds.



5. The Battery Voltage Screen appears for a few seconds.



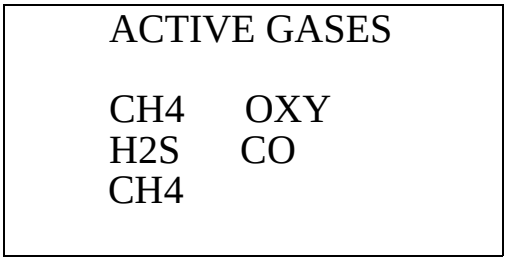
6. The Mode Select Screen displays.



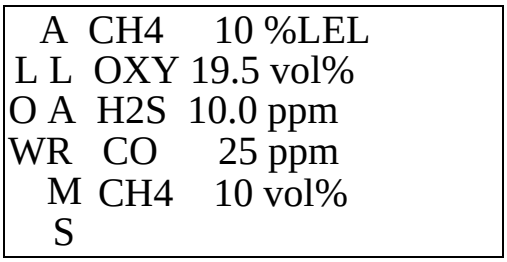
7. The cursor will flash in front of **NORMAL MODE**. Use the RANGE ▼SHIFT button to move the cursor next to **BAR HOLE MODE**.
8. With Bar Hole Mode selected, press and release the POWER ENTER RESET button to begin the Bar Hole Mode startup sequence.

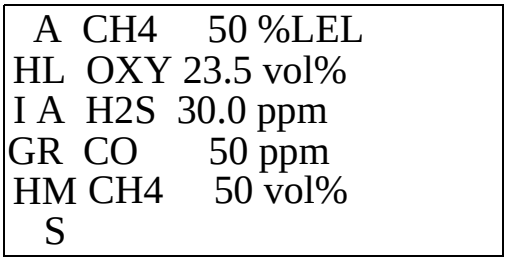
NOTE: If no button is pressed for 20 seconds, the unit will proceed into whichever mode has the cursor in front of it.

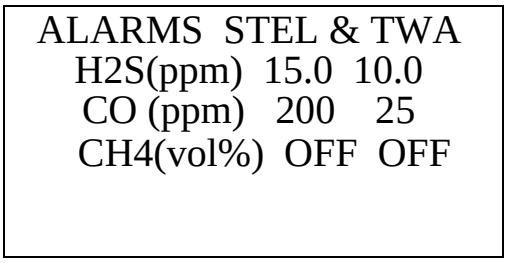
9. The Active Gases Screen appears for a few seconds indicating which channels are active and their target gas.



10. The gas alarm setpoints are displayed by three screens in sequence: the Low Alarm Screen, High Alarm Screen, and STEL/TWA Alarm Screen. Each screen remains on the LCD for three seconds.

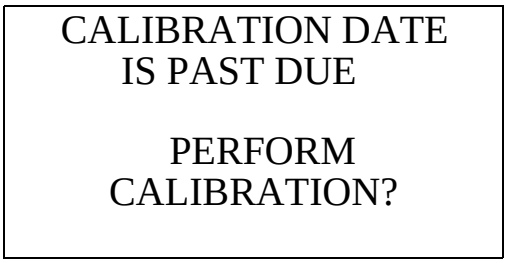






11. After the alarm screens, if CAL REMINDER is turned on, the screen that appears next depends on how CAL PAST DUE ACT is set in the Setup Mode Menu (see “Updating the Calibration Past Due Action Setting” on page 119).

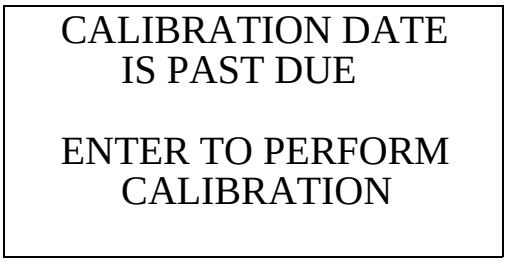
- If the unit is due for calibration and CAL PAST DUE ACT is set to CONFIRM TO CAL, then the following screen displays and the buzzer sounds in a double pulsing pattern.



  To perform a calibration, press and release the AIR ▲ YES button. The EAGLE 2 will enter Calibration Mode and the LCD will show the Calibration Mode main menu. See “Chapter 4: Calibration Mode” on page 55 for instructions to calibrate the EAGLE 2. When you are done with the calibration and exit Calibration Mode, the unit will begin the startup sequence. If the calibration was successful, the screen above will not appear again until the unit is due for calibration. If the calibration was not successful, the screen above will again appear in the startup sequence.

  To continue without performing a calibration, press and release the DISPLAY ADJUST NO button.

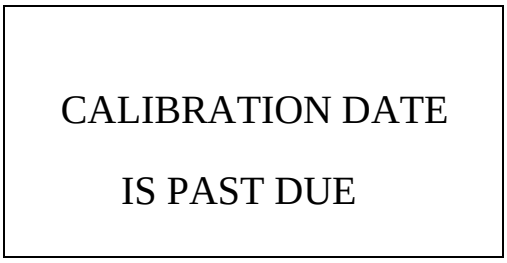
- If the unit is due for calibration and CAL PAST DUE ACT is set to MUST CALIBRATE, then the following screen displays and the buzzer sounds in a double pulsing pattern.



  The EAGLE 2 cannot be used until a successful calibration has been performed. Press and release the ENTER button to enter Calibration Mode. See “Chapter 4: Calibration Mode” on page 55 for instructions to calibrate the EAGLE 2. When you are done with the calibration and exit Calibration Mode, the unit will begin the startup sequence. If the calibration was successful, the screen above will not appear again until the unit is due for calibration. If the calibration was not successful, the screen above will again appear in the startup sequence.

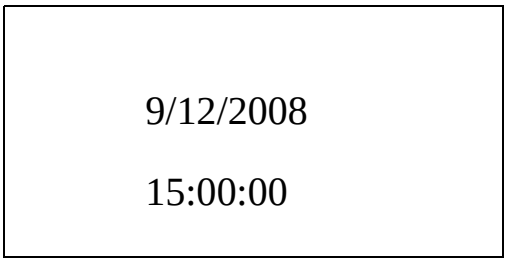
- If the unit is due for calibration and CAL PAST DUE ACT is set to

NOTIFICATION ONLY, then the following alert screen displays and the buzzer sounds in a double pulsing pattern.

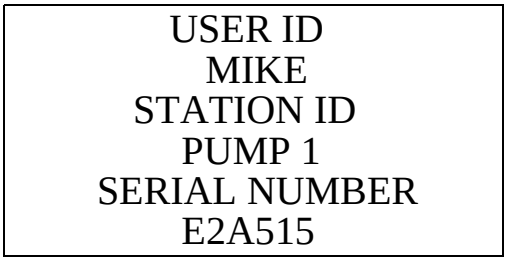


Press and release the POWER ENTER RESET button to acknowledge the alert and continue with the startup sequence.

12. The Date/Time Screen appears for a few seconds.

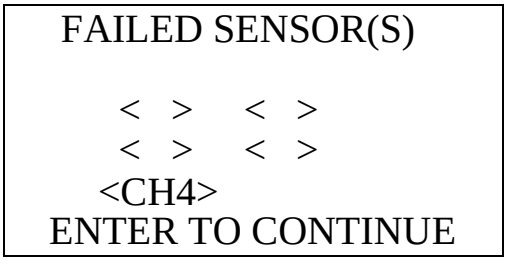


13. If USER/STATION ID is turned on (see “Turning the User/Station ID Function On or Off” on page 113), the ID Screen appears for a few seconds.



If USER/STATION ID is turned off, only the serial number is shown.

14. If the EAGLE 2 experiences a sensor failure during start up, a screen indicating which sensor failed appears and the buzzer sounds a pulsing tone twice per second. In the example below, the TC %volume CH_4 sensor has failed.



If one of the combustible sensors, LEL or TC, fails, it is not possible to enter Bar Hole Mode. Press and release the POWER ENTER RESET button to acknowledge the failure and return to the Mode Select Screen. Replace the failed sensor as soon as possible.

If the oxygen sensor fails, press and release the POWER ENTER RESET button to acknowledge the failure and continue to Bar Hole Mode. The gas reading for the oxygen sensor will be replaced by "XXX". Replace the failed sensor as soon as possible.

If any other sensor that is installed fails, press and release the POWER ENTER RESET button to acknowledge the failure and continue to Bar Hole Mode. Replace the failed sensor(s) as soon as possible for use in Normal Mode.

15. The EAGLE 2 is now operating in Bar Hole Mode. The pump is off and the following screen appears.

```
BAR HOLE MODE

CH4          0 %LEL
OXY       20.9 vol%
ENTER: MEASURE
ADJUST: PURGE
```

Only the methane and oxygen channels are displayed.

NOTE: The units for the methane channel can be changed using the RANGE ▼ SHIFT button. Press and release the RANGE ▼ SHIFT button until the desired units, ppm, LEL, or vol%, are displayed.

NOTE: If measuring the combustible gas in ppm units, for maximum sensor stability, allow 3-5 minutes for the sensor to warm up. The small increment size in the lower range of a ppm measurement can cause instability if the unit is not properly warmed up.

Performing a Demand Zero, Bar Hole Mode

Before using the EAGLE 2, it is a recommended to set the fresh air readings for the target gases by performing a demand zero. This will set the CH_4 channel to zero and the OXY channel to 20.9%.

1. Find a fresh-air environment. This is an environment free of toxic or combustible gases and of normal oxygen content (20.9%).
2. Turn on the unit as described above in "Turning On the EAGLE 2, Bar Hole Mode" on page 246.

3. Press and hold the AIR ▲ YES button. The display will indicate that a demand zero is taking place and prompt you to hold the AIR ▲ YES button.
4. Continue to hold the AIR ▲ YES button until the display prompts you to release it. The EAGLE 2 will set the fresh air reading for the CH_4 and oxygen channels. Start up is complete and the unit is now ready for bar hole testing.

Bar Hole Testing

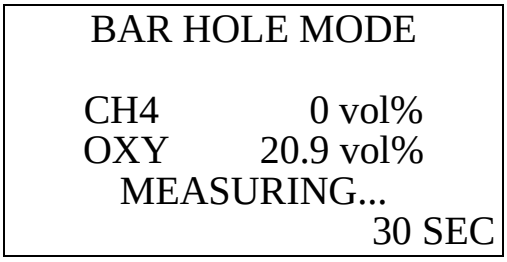
In Bar Hole Mode, the you can initiate sampling for a fixed time period to monitor for methane and oxygen in a bar hole. The factory set time is 30 seconds. At the end of the sample period, the pump will shut off and the peak methane and minimum oxygen levels monitored during the sample period will be displayed. Bar Hole Mode also allows you to initiate an air purge cycle to purge gas from the EAGLE 2 after a sample is taken. See “Setting the Bar Hole Measurement Time” on page 121 to change the bar hole sample time.

In a low-light environment, press and release the RANGE ▼ SHIFT button to turn on the display backlight. Although the backlight will turn on when any button is pressed, other buttons may initiate an undesired operation sequence. See “Updating the Backlight Delay Setting” on page 115 to program backlight duration. If CONFIRMATION ALERT is turned on in the Setup Mode menu, the EAGLE 2 will alert you based on the setting you choose once every 15 minutes to confirm that it’s operating.

Performing a Bar Hole Test

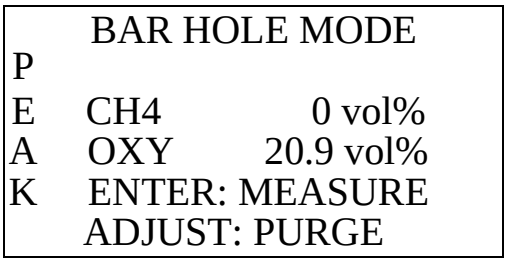
1. Start up the EAGLE 2 as described in “Start Up, Bar Hole Mode” on page 246.
2. Take the EAGLE 2 to the bar hole that will be tested.

3. Insert the probe into the bar hole and press and release the ENTER button. The pump will turn on, the display will indicate "MEASURING..." below the oxygen reading, and the sample period will begin with the sample period counting down in seconds in the lower right corner of the display. The CH_4 channel will be displayed in vol%.



4. After 15 seconds of sampling, if the CH_4 reading is less than 5 vol%, the CH_4 channel will automatically begin displaying in the units you selected earlier. If you selected the methane channel to be displayed in vol%, then after 15 seconds, the reading will remain in vol%.

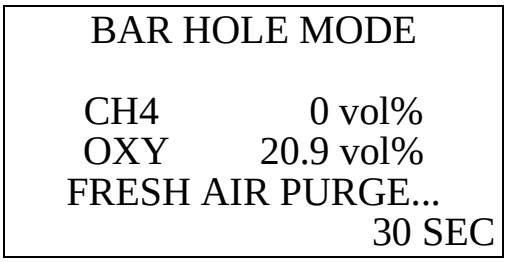
5. At the end of the sample period, the pump will shut off and the audible alarm will sound, then the peak methane reading and the minimum oxygen reading for the sample period will be displayed.



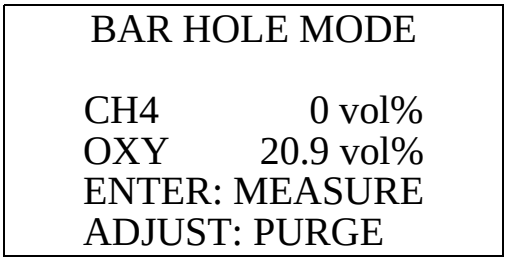
6. If a high concentration of methane is encountered, a fresh air purge can be performed to purge the hose, probe and EAGLE 2 of gas before the next bar hole test. To perform a purge, do the following:

   - Remove the probe from the barhole so the instrument will draw fresh air.

- Press and release the DISPLAY ADJUST NO button. The display will now indicate “FRESH AIR PURGE . . .” below the oxygen reading and the purge time will begin counting down from 30 seconds in the lower right corner of the display.



- After 15 seconds of sampling, if the CH_4 reading is less than 5 vol%, the CH_4 channel will automatically begin displaying in the units you selected earlier. Since performing a fresh air purge draws fresh air, the display units should always switch to the previously selected units. If you selected the methane channel to be displayed in vol%, then after 15 seconds, the reading will remain in vol%.
- When the purge is complete, the screen will return to the initial Bar Hole Mode screen.



7. If other bar holes will be tested, proceed to the next bar hole and repeat Step 3 - Step 6.
8. To cancel a bar hole measurement or fresh air purge that is in progress, press and release the DISPLAY ADJUST NO button.
9. To exit Bar Hole Mode and return to the Mode Select Screen at any time, press and hold the RANGE ▼SHIFT button for 5 seconds.

Turning Off the EAGLE 2, Bar Hole Mode

1. Press and hold the POWER ENTER button.
2. The unit will initiate a bar hole measurement. Keep holding the POWER ENTER button. The buzzer will sound and the LCD back light will flash for about five seconds.
3. Release the button when GOODBYE appears on the display. When GOODBYE disappears and the backlight turns off, the unit is off.

Appendix L: Using the EAGLE 2 in Leak Check Mode

Overview

This chapter explains how to operate the EAGLE 2 in Leak Check Mode. Leak Check Mode is used to pinpoint small leaks of combustible gas from valves, flanges, connections, and other potential leak points. When the EAGLE 2 is in Leak Check Mode, only the catalytic combustible sensor is active.

If an EAGLE 2 is intended for tracking down leaks, it is shipped with Leak Check Mode or both Leak Check Mode and Bar Hole Mode enabled so that the operator must choose which operational mode to use when the unit is turned on (see "Updating LC/BH Mode Setting" on page 120).

Start Up, Leak Check Mode

This section explains how to start up the EAGLE 2 in Leak Check Mode and get it ready for operation.

Turning On the EAGLE 2, Leak Check Mode

CAUTION: *If one or more sensors other than a catalytic combustible sensor is installed, these sensors will not be active while the EAGLE 2 is in Leak Check Mode.*

The following description of the EAGLE 2 start up sequence assumes that the following menu items in Setup Mode are turned on: CAL REMINDER and USER/STATION ID. If either of these items is turned off, then the corresponding screen will not appear.

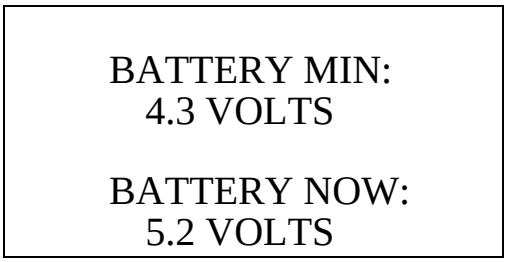
1. Connect the standard probe to the EAGLE 2's quick connect inlet fitting.

NOTE: Use the standard probe, not the bar hole probe, when using the EAGLE 2 in Leak Check Mode.

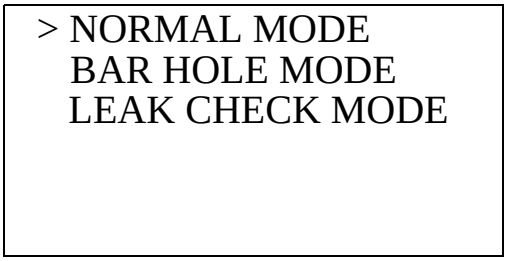
2. If a sample hose is used, connect the sample hose to the EAGLE 2's quick connect inlet fitting and connect the probe to the sample hose's quick connect fitting.
3. Press and briefly hold down the POWER ENTER RESET button. Release the button when you hear a beep.

4. The LCD will show the following screen for about ten seconds.

5. The Battery Voltage Screen appears for a few seconds.



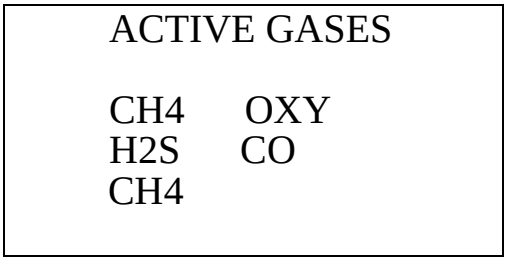
6. The Mode Select Screen displays.



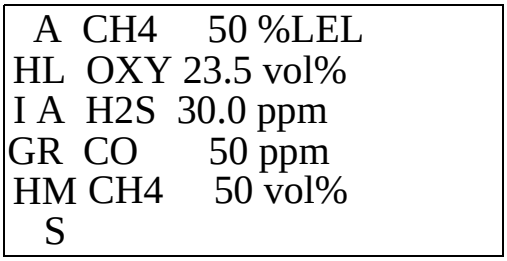
7. The cursor will flash in front of **NORMAL MODE**. Use the RANGE ▼ SHIFT button to move the cursor next to **LEAK CHECK MODE**.
8. With Leak Check Mode selected, press and release the POWER ENTER RESET button to begin the Leak Check Mode startup sequence.

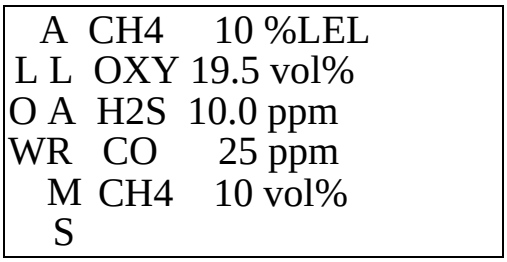
NOTE: If no button is pressed for 20 seconds, the unit will proceed into whichever mode has the cursor in front of it.

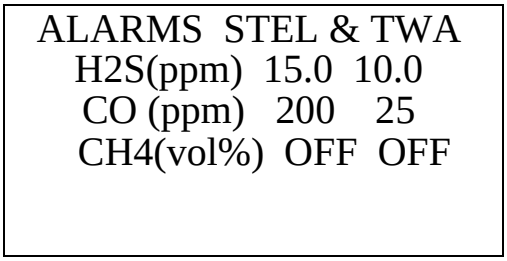
9. The Active Gases Screen appears for a few seconds indicating which channels are active and their target gas.



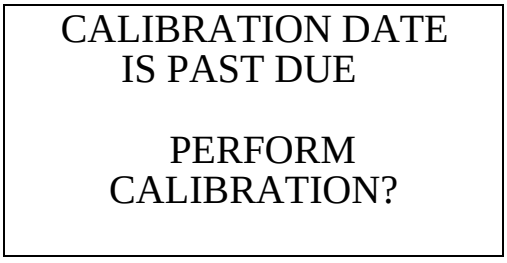
10. The gas alarm setpoints are displayed by three screens in sequence: the Low Alarm Screen, High Alarm Screen, and STEL/TWA Alarm Screen. Each screen remains on the LCD for three seconds.







11. After the alarm screens, if CAL REMINDER is turned on, the screen that appears next depends on how CAL PAST DUE ACT is set in the Setup Mode Menu (see “Updating the Calibration Past Due Action Setting” on page 119).
    - If the unit is due for calibration and CAL PAST DUE ACT is set to CONFIRM TO CAL, then the following screen displays and the buzzer sounds in a double pulsing pattern.

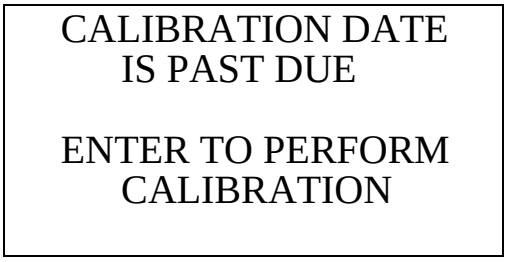


      To perform a calibration, press and release the AIR ▲ YES button. The EAGLE 2 will enter Calibration Mode and the LCD will show the Calibration Mode main menu. See “Chapter 4: Calibration Mode” on page 55 for instructions to calibrate the EAGLE 2. When you are

done with the calibration and exit Calibration Mode, the unit will begin the startup sequence. If the calibration was successful, the screen above will not appear again until the unit is due for calibration. If the calibration was not successful, the screen above will again appear in the startup sequence.

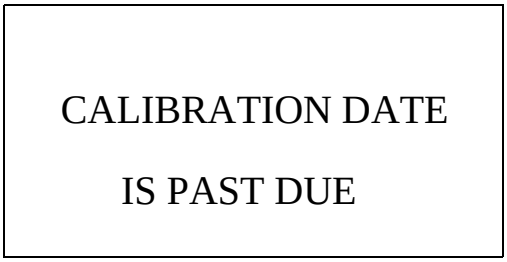
To continue without performing a calibration, press and release the DISPLAY ADJUST NO button.

- If the unit is due for calibration and CAL PAST DUE ACT is set to MUST CALIBRATE, then the following screen displays and the buzzer sounds in a double pulsing pattern.



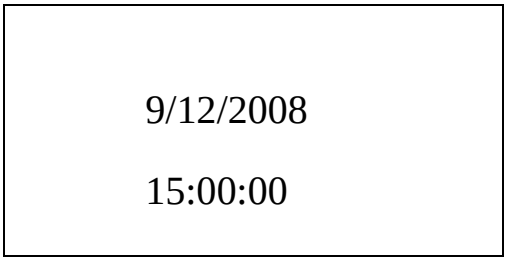
The EAGLE 2 cannot be used until a successful calibration has been performed. Press and release the ENTER button to enter Calibration Mode. See “Chapter 4: Calibration Mode” on page 55 for instructions to calibrate the EAGLE 2. When you are done with the calibration and exit Calibration Mode, the unit will begin the startup sequence. If the calibration was successful, the screen above will not appear again until the unit is due for calibration. If the calibration was not successful, the screen above will again appear in the startup sequence.

- If the unit is due for calibration and CAL PAST DUE ACT is set to NOTIFICATION ONLY, then the following alert screen displays and the buzzer sounds in a double pulsing pattern.

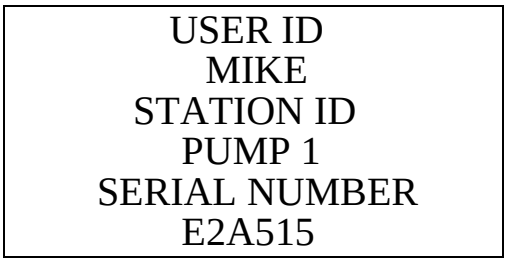


Press and release the POWER ENTER RESET button to acknowledge the alert and continue with the startup sequence.

12. The Date/Time Screen appears for a few seconds.

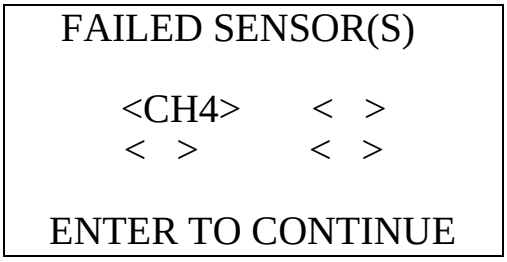


13. If USER/STATION ID is turned on (see “Turning the User/Station ID Function On or Off” on page 113), the ID Screen appears for a few seconds.



If USER/STATION ID is turned off, only the serial number is shown.

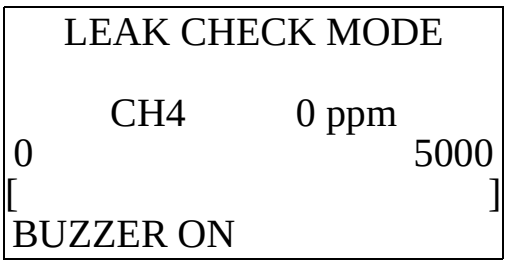
14. If the EAGLE 2 experiences a catalytic combustible sensor failure during start up, a screen indicating which sensor failed appears and the buzzer sounds a pulsing tone twice per second. In the example below, the H_2S sensor has failed.



If the catalytic combustible sensor fails, it is not possible to enter Leak Check Mode. Press and release the POWER ENTER RESET button to acknowledge the failure and return to the Mode Select Screen. Replace the failed sensor.

If any other sensor that is installed fails, press and release the POWER ENTER RESET button to acknowledge the failure and continue to Leak Check Mode. Change the failed sensor(s) as soon as possible for use in Normal Mode.

15. The EAGLE 2 is now operating in Leak Check Mode. The pump is on and the following screen appears.



NOTE: For maximum sensor stability, allow 3-5 minutes for the sensor to warm up. The small increment size in the lower range of a ppm measurement can cause instability if the unit is not properly warmed up.

Performing a Demand Zero, Leak Check Mode

Before using the EAGLE 2, it is recommended to set the fresh air reading for the target gas by performing a demand zero. This will set the CH_4 channel to zero.

1. Find a fresh-air environment. This is an environment free of toxic or combustible gases and of normal oxygen content (20.9%).
2. Turn on the unit as described above in "Turning On the EAGLE 2, Leak Check Mode".
3. Press and hold the AIR ▲ YES button. The display prompts you to hold the AIR ▲ YES button.
4. Continue to hold the AIR ▲ YES button until the display prompts you to release it. The EAGLE 2 will set the fresh air reading for the CH_4 channel. Start up is complete and the unit is now ready for monitoring.

Leak Testing

In Leak Check Mode, the EAGLE 2 only displays combustible gas readings. The readings are displayed in both numerical and bar graph form. The bar graph displays readings up to 5,000 ppm while the numerical indicator displays readings up to 50,000 ppm in the following increments:

- 5 ppm increments from 0 ppm to 200 ppm
- 10 ppm increments from 200 ppm to 1,000 ppm
- 50 ppm increments from 1,000 ppm to 10,000 ppm

- 250 ppm increments from 10,000 ppm to 50,000 ppm

As the gas concentration increases from 0 ppm, the alarm LEDs begin to blink in unison with the buzzer's pulsing. The blinking / pulsing rate increases as the gas reading increases. If desired the buzzer can be turned off in Leak Check Mode.

In a low-light environment, press and release any of the buttons to turn on the display backlight. See "Updating the Backlight Delay Setting" on page 115 to program backlight duration. If CONFIRMATION BEEP is turned on in the Setup Mode menu, the EAGLE 2 beeps once every 15 minutes to confirm that it's operating.

Locating a Leak

1. Start up the EAGLE 2 as described above in "Start Up, Leak Check Mode" on page 255.
2. Move the probe tip back and forth along the area where a leak is suspected.
3. Observe the display reading. If the gas level increases, the numerical reading will increase, the bar graph level will increase to the right, and the beeping and buzzer pulsing frequency will increase.
4. Use the increasing and decreasing of the reading to locate the leak point.
5. To exit Leak Check Mode and return to the Mode Select Screen at any time, press and hold the RANGE ▼SHIFT button for 5 seconds.

Turning the Buzzer On and Off in Leak Check Mode

The alarm buzzer can be turned off and on when the EAGLE 2 is in Leak Check Mode. This setting only applies to Leak Check Mode and does not affect buzzer operation in Normal or Bar Hole Mode. The buzzer setting is displayed in the lower left corner as **BUZZER ON** when the buzzer is on or **BUZZER OFF** when the buzzer is off. When the EAGLE 2 is turned off or you exit Leak Check Mode, it remembers the buzzer setting. So when the EAGLE 2 is turned on again or you return to Leak Check Mode after operating in Normal Mode or Bar Hole Mode, the buzzer has the same setting it did the last time it was in Leak Check Mode.

To turn the buzzer off or on while in Leak Check Mode, press and release the DISPLAY ADJUST NO button.

Turning Off the EAGLE 2, Leak Check Mode

1. Press and hold the POWER button.
2. The buzzer will sound and the LCD back light will flash for about five seconds.
3. Release the button when GOODBYE appears on the display. When GOODBYE disappears and the backlight turns off, the unit is off.

Appendix M: Tank Tester Model

The EAGLE 2 Tank Tester model is intended for checking tanks or vessels that may contain residual hydrocarbon vapors or water or may have been purged of oxygen. It is supplied as an LEL (catalytic) only unit or an LEL (catalytic) / oxygen unit. You can also use this model as a standard EAGLE 2 gas monitor by connecting the standard hose and probe and selection Normal Mode in the Inert Mode Selection Screen.

Table 33: Alarm Points for Tank Tester Configuration

	Alarm 1	Alarm 2
LEL	10% LEL 1100 ppm	50% LEL 5500 ppm
Normal Mode Oxygen	Oxy: 19.5% falling	Oxy: 23.5% rising
Inert Mode Oxygen	Oxy: 5.0% rising	Oxy: 10.0% rising

Description

The tank tester model has an additional socket on the front on the housing to accommodate connection of the float probe assembly.

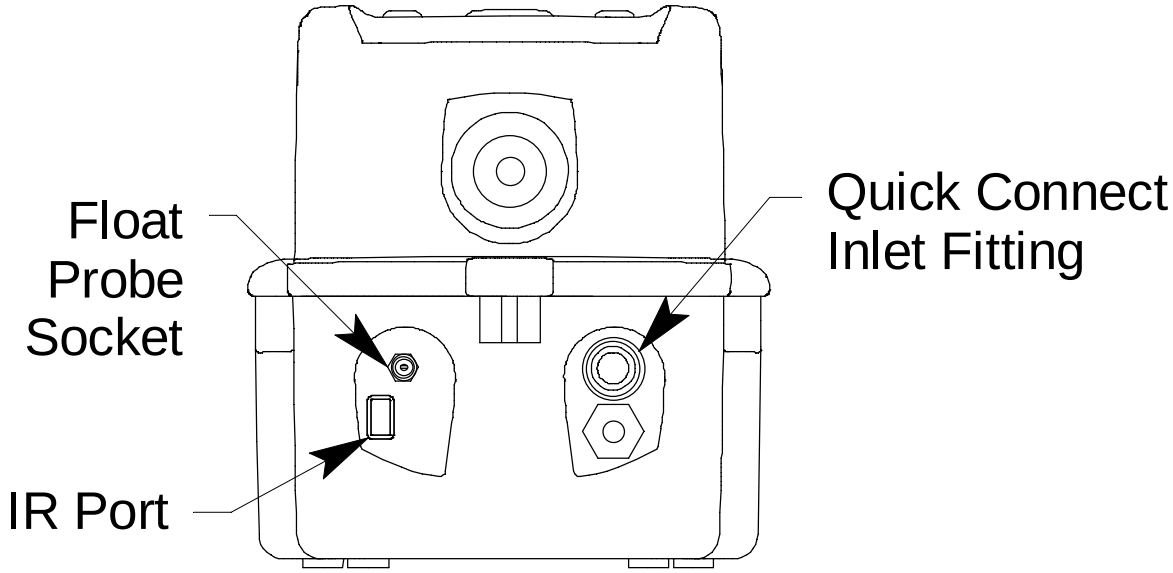


Figure 41: EAGLE 2 Tank Tester Version

This model includes the following non-standard components.

Float Probe Assembly

The float probe assembly helps prevent liquid from being drawn into the EAGLE 2. The float probe assembly is 12-feet long. The hose between both ends of the float probe has an integral cable that connects a switch in the float end to the plug at the other end. This plug connects to the float probe socket that is adjacent to the EAGLE 2's IR port. A quick connect fitting at the same end of the assembly connects to the EAGLE 2's inlet fitting. The float probe switch at the opposite end of the 12-foot hose shuts off the pump if the probe begins to be submerged into a liquid.

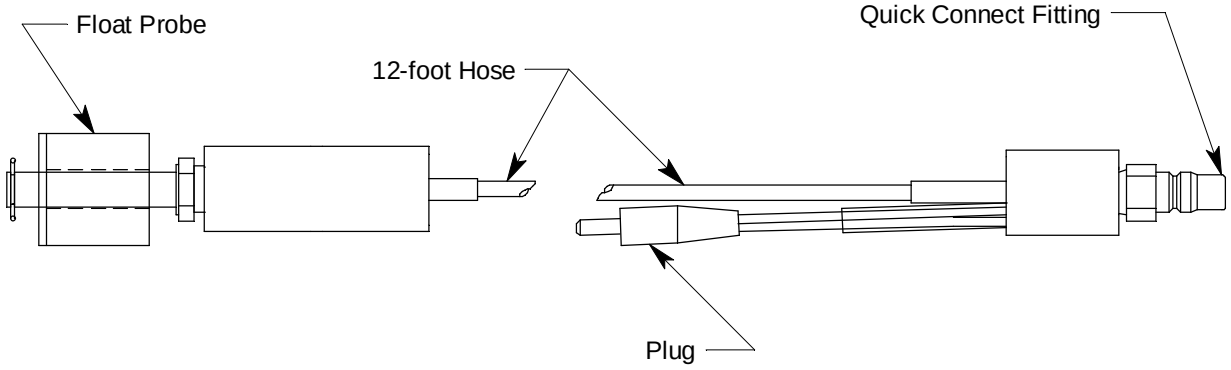


Figure 42: Float Probe Assembly

To use the float probe assembly:

CAUTION: *Drawing water, gasoline, or other liquids into the EAGLE 2 will cause damage.*

1. Attach the quick connect fitting to the EAGLE 2's inlet fitting.
2. Insert the plug into the socket that is adjacent to the IR port.
3. Lower the probe into the tank or vessel. Lower the probe *very slowly,* keeping th efloat switch vertical, to allow the float switch to activate if necessary.

Dilution Fitting (1:1)

CAUTION: *When measuring oxygen readings, remove the dilution fitting or use your finger to seal the small dilution hole on the side of the dilution fitting.*

The catalytic combustible gas sensor requires oxygen to operate. In environments where there is not enough oxygen to operate the combustible gas sensor, (for example a tank purged with an inerting gas), the 1:1 dilution fitting adds sufficient oxygen by blending ambient air with the incoming sample. The standard dilution fitting

dilutes at a ratio of 1:1 (one part air to one part sample). The dilution fitting is not an integral part of the float probe assembly and must be installed on the EAGLE 2 inlet fitting before installing the float probe assembly when measuring gas in an inert atmosphere.

To attach the dilution fitting:

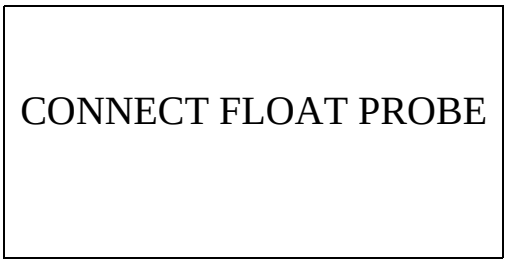
1. Attach the dilution fitting's male quick connect fitting to the EAGLE 2's inlet fitting.
2. Attach the float probe assembly to the opposite end of the dilution fitting.

NOTE: When using the dilution fitting, multiply the combustible gas reading (LEL or PPM) by 2 to determine the actual combustible gas concentration. Always remove the dilution fitting or seal the dilution hole with your finger to measure for oxygen.

Start Up

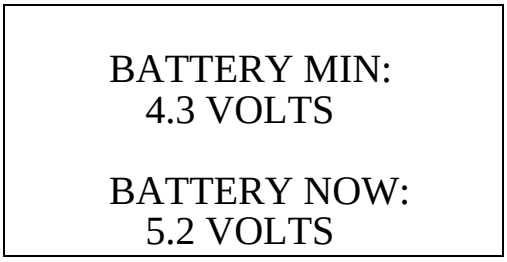
1. Press and briefly hold down the POWER ENTER RESET button. Release the button when you hear a beep.
2. The LCD will show the following screen for about ten seconds.

3. The Connect Float Probe Screen appears for a few seconds prompting you to confirm that the float probe's quick connect fitting is connected to the EAGLE 2's inlet fitting and that the float probe's plug is connected to the EAGLE 2.

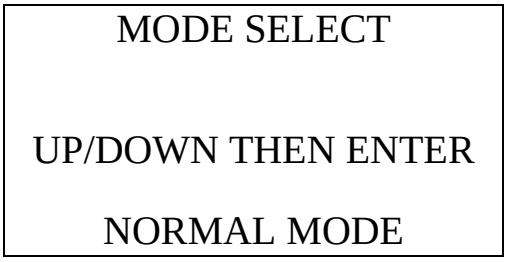


Make sure that the float probe assembly is hanging vertically and that the float device is located at the bottom of the probe.

4. The Battery Voltage Screen appears for a few seconds.



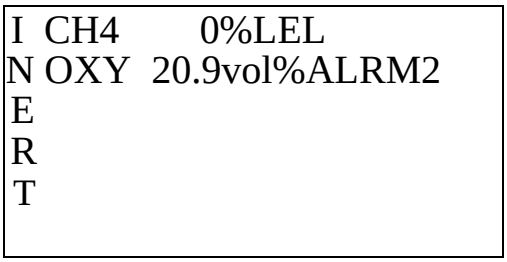
5. The Inert Mode Selection Screen will then be displayed.



Use the AIR ▲ YES or RANGE ▼ SHIFT button to display the mode you wish to enter. To use the EAGLE 2 for tank tester applications, ensure that the float probe is connected and select Inert Mode. To use the EAGLE 2 in Normal Mode, select Normal Mode and refer to "Measuring Mode, Normal Operation" on page 29. If you have not made a selection after 20 seconds, the instrument will begin to beep and the LEDs will begin to flash. They will continue until you make a selection.

WARNING: The EAGLE 2 is not a gas monitoring device until you select a mode and enter it.

6. The warm up sequence will continue as described in "Start Up" on page 22. The oxygen alarms in the alarm point screens will be the alarm points for Inert Mode and not for Normal Mode.
7. When the warm up is complete and the instrument is operating in Inert Mode, the screen will appear as shown below if the instrument is sampling a fresh air environment. The screen is shown with %LEL and oxygen channels. Your unit may only have %LEL.



If the instrument is sampling a fresh air environment, the oxygen channel will be in alarm. For more information about Inert Mode, see “Appendix N: Using the EAGLE 2 in Inert Mode” on page 269.

Alarms

The EAGLE 2 Tank Tester model has two sets of oxygen alarm settings, one for Normal Mode and one for Inert Mode. The Inert Mode oxygen alarms are factory-set at 5.0% by volume (rising) and 10.0% by volume (rising). Normal Mode oxygen alarm setpoints also exist and take effect when you select Normal Mode at start up.

The *rising* Inert Mode alarms are used to monitor a purged vessel to alert you to a rising oxygen condition.

The oxygen level level in a fresh air environment is above both Inert Mode oxygen alarm points so the EAGLE 2 Tank Tester version *will* go into alarm when turned on in Inert Mode in a fresh air environment. To silence the alarm, press the RESET button. The audible alarm silences, but the alarm lights continue to flash and the display screen continues to indicate an oxygen alarm. If one of the alarm levels is newly exceeded, the audible alarm sounds again.

For information about viewing and changing the standard alarms used in Normal Mode, see “Updating the Alarm Point Settings” on page 110. For information about viewing and changing Inert Mode oxygen alarms, see “Appendix N: Using the EAGLE 2 in Inert Mode” on page 269.

Calibration

Use a hexane calibrating source to calibrate the combustible gas LEL range. Use a 100% nitrogen calibrating source to set the zero reading for the oxygen channel. RKI Instruments, Inc. recommends using the Single Calibration method to calibrate the EAGLE 2 Tank Tester model. See “Chapter 4: Calibration Mode” on page 55. The instructions in that section call for calibrating the EAGLE 2 with methane. When following these instructions, be sure to calibrate with hexane rather than methane.

NOTE: Do not calibrate the EAGLE 2 Tank Tester model with the dilution fitting attached to the inlet fitting.

Parts List

Table 34 lists part numbers for replacement parts and accessories of the EAGLE 2's Tank Tester model.

Table 34: Parts List: EAGLE 2 Tank Tester Model

Part Number	Description
80-0405RK	Dilution fitting (1:1)
80-0802RK	Float probe (12-foot)

Appendix N: Using the EAGLE 2 in Inert Mode

Inert Mode is used to measure the combustible gas and / or oxygen level in a purged environment. The oxygen alarms in this mode are both increasing and are generally set at 5.0% and 10.0%.

Description

Inert Mode is factory activated for instruments that require it. The instrument can still be used in Normal Mode for other applications.

It is recommended that either an IR CH_4 or an IR HC sensor be installed in a unit that is used to monitor combustible gas in Inert Mode since it does not require oxygen to work properly. The catalytic LEL sensor does not operate at oxygen concentrations below 10% volume. If it is necessary to use the catalytic LEL sensor in Inert Mode, a dilution fitting must be installed. Installing a dilution fitting will affect the oxygen reading since you're introducing oxygen into the sample.

Alarms

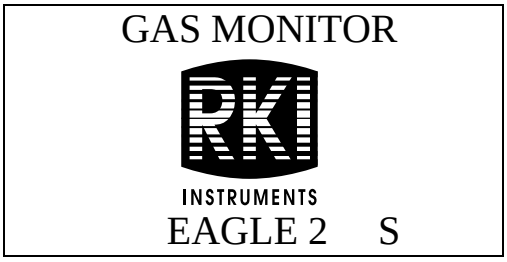
The oxygen channel alarm points in Inert Mode are different from those in Normal Mode. All other alarm point settings remain unchanged.

Since the application for Inert Mode is to detect a rising oxygen level in purged environments, both oxygen alarms are set to rising. The factory set alarm point is 5.0% volume for the low alarm and 10.0% volume for the high alarm. These alarm points are user adjustable in Setup Mode. See "Updating the Alarm Point Settings" on page 110 for instructions to set the alarm points for channels other than oxygen or to set the Normal Mode oxygen alarm points.

Below are instructions to set the Inert Mode oxygen alarms.

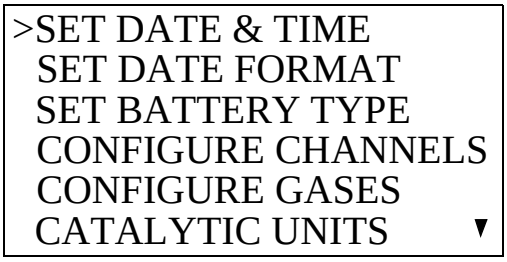
1. Take the EAGLE 2 to a non-hazardous location and turn it off if it is on.
2. Press and hold the AIR ▲ YES or RANGE ▼ SHIFT buttons, then press and hold the POWER ENTER RESET button. When you hear a beep, release the buttons.
3. The LCD will show the following screen for a few seconds with the "S" in the lower right corner indicating the unit is entering

Setup Mode.

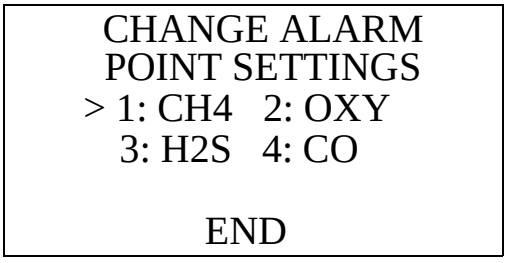


4. The “S” will then disappear and the following screen will appear for a few seconds.

5. If the unit prompts you for the password, enter it by using the AIR ▲ YES or RANGE ▼ SHIFT buttons to select each password number and then pressing and releasing the POWER ENTER RESET button to enter it and move on to the next number until all of the numbers are entered. The main menu displays. It displays six menu items at a time.

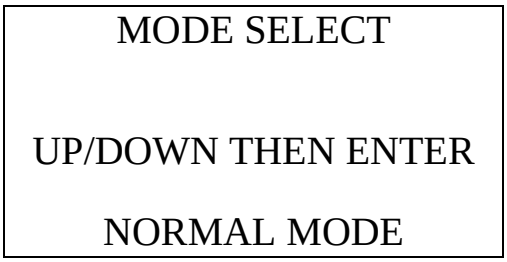


6. Use the AIR ▲ YES or RANGE ▼ SHIFT button to move the cursor to the **ALARM POINTS** menu item.
7. Press and release POWER ENTER RESET. The Change Alarm Point Settings Screen appears and all detection channels are displayed.

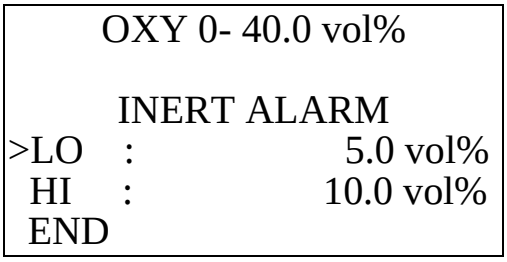


8. Move the cursor next to the oxygen channel. Press and release POWER ENTER RESET.

9. A mode select screen will appear and prompt you to choose between Normal Mode and Inert Mode. Use the AIR ▲ YES or RANGE ▼ SHIFT button to display Inert Mode and press and release POWER ENTER RESET.



NOTE: To change the Normal Mode oxygen other alarm points, select Normal Mode and see "Updating the Alarm Point Settings" on page 110.



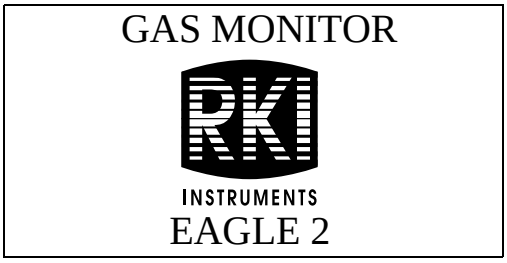
10. Press and release POWER ENTER RESET. The alarm point or alarm operation (oxygen only) will begin to flash.
11. Use AIR ▲ YES and RANGE ▼ SHIFT to adjust the alarm point to the desired setting. Keep the following in mind:
    - The low alarm cannot be set higher than the high alarm and the high alarm cannot be set lower than the low alarm.
    - Any alarm setting can be turned off by adjusting it to its lowest setting. The setting will be displayed as **OFF.**
12. If you want to continue with the change, press and release POWER ENTER RESET to accept the setting.

    If you want to exit this screen without saving any change to the alarms, press and release DISPLAY ADJUST NO until you return to the Change Alarm Point Settings Screen.
13. When you are done making changes, use RANGE ▼ SHIFT to move the cursor next to **END**.

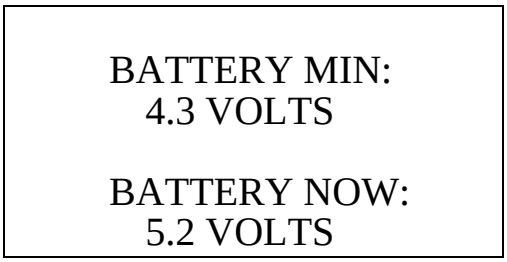
14. Press and release POWER ENTER RESET to save the new settings and return to the Change Alarm Point Settings Screen.
15. Use RANGE ▼SHIFT to move the cursor next to **END.**
16. Press and release POWER ENTER RESET to return to the main menu.

Start Up

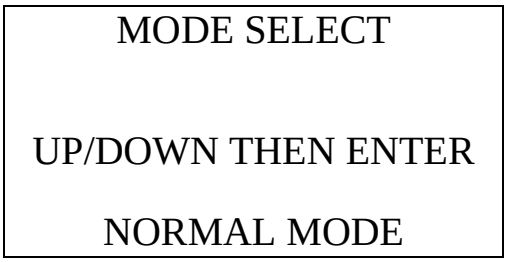
1. Press and briefly hold down the POWER ENTER RESET button. Release the button when you hear a beep.
2. The LCD will show the following screen for about ten seconds.



3. The Battery Voltage Screen appears for a few seconds.



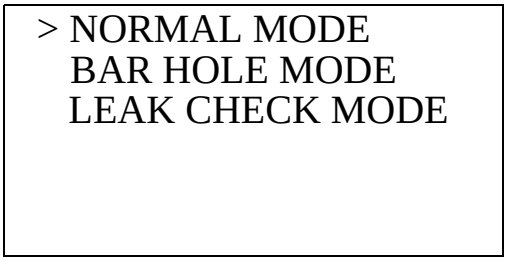
4. The Inert Mode Selection Screen will then be displayed.



Use the AIR ▲ YES or RANGE ▼SHIFT button to display the mode you wish to enter. If you have not made a selection after 20 seconds, the instrument will begin to beep and the LEDs will begin to flash. They will continue until you make a selection.

WARNING: The EAGLE 2 is not a gas monitoring device until you select a mode and enter it.

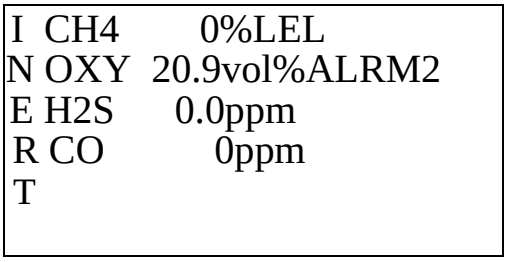
5. If you select Normal Mode, the warm up sequence will continue as described in “Start Up” on page 22 unless Leak Check or Bar Hole Mode is active. If Leak Check or Bar Hole Mode is active, the Leak Check/Bar Hole Mode Select Screen will appear immediately after the Normal Mode selection.



   Use the AIR ▲ YES or RANGE ▼ SHIFT button to display the mode you wish to enter.

6. If you select Inert Mode, the warm up sequence will continue as described in “Start Up” on page 22. The oxygen alarms in the alarm point screens will be the alarm points for Inert Mode and not for Normal Mode.

7. When the warm up is complete and the instrument is operating in Inert Mode, the screen will appear as shown below if the instrument is sampling a fresh air environment.



   If the instrument is sampling a fresh air environment, the oxygen channel will be in alarm.

See “Measuring Mode, Normal Operation” on page 29 for operating instructions keeping in mind that the Inert Mode oxygen alarm settings are different.

You can access the Inert Mode Selection Screen while in Inert Mode or Normal Mode by pressing and holding the RANGE ▼ SHIFT button.

MODE SELECT
UP/DOWN THEN ENTER
NORMAL MODE

Use the AIR ▲ YES or RANGE ▼ SHIFT button to display the mode you wish to enter and press and release the POWER ENTER RESET button.

Warranty

RKI Instruments, Inc. warrants the EAGLE 2 sold by us to be free from defects in materials, workmanship, and performance for a period of two years from the date of shipment from RKI Instruments, Inc. This includes the instrument and the original sensors. Replacement parts are warranted for 1 year from the date of their shipment from RKI Instruments, Inc. Any parts found defective within their warranty period will be repaired or replaced, at our option, free of charge. This warranty does not apply to those items which by their nature are subject to deterioration or consumption in normal service, and which must be cleaned, repaired, or replaced on a routine basis. Examples of such items are:

Absorbent cartridges

Filter elements, disks, or sheets

Pump diaphragms and valves

Warranty is voided by abuse including mechanical damage, alteration, rough handling, or repair procedures not in accordance with the instruction manual. This warranty indicates the full extent of our liability, and we are not responsible for removal or replacement costs, local repair costs, transportation costs, or contingent expenses incurred without our prior approval.

THIS WARRANTY IS EXPRESSLY IN LIEU OF ANY AND ALL OTHER WARRANTIES AND REPRESENTATIONS, EXPRESSED OR IMPLIED, AND ALL OTHER OBLIGATIONS OR LIABILITIES ON THE PART OF RKI INSTRUMENTS, INC. INCLUDING BUT NOT LIMITED TO THE WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL RKI INSTRUMENTS, INC. BE LIABLE FOR INDIRECT, INCIDENTAL, OR CONSEQUENTIAL LOSS OR DAMAGE OF ANY KIND CONNECTED WITH THE USE OF ITS PRODUCTS OR FAILURE OF ITS PRODUCTS TO FUNCTION OR OPERATE PROPERLY.

This warranty covers instruments and parts sold to users only by authorized distributors, dealers, and representatives as appointed by RKI Instruments, Inc.

We do not assume indemnification for any accident or damage caused by the operation of this gas monitor and our warranty is limited to replacement of parts or our complete goods.

B10. Procedures for Field Measurement of Wind Speed and Direction using Portable/Hand-Held Instruments

ARCADIS
Infrastructure, environment, facilities

Imagine the result

Procedures for Field Measurement of Wind Speed and Direction using Portable/Hand-Held Instruments

Rev. #: 01

Rev Date: July 24, 2012

Approval Signatures

Prepared by: _____ Date: _____

Andrew Korik, CCM

Reviewed by: _____ Date: _____

Mark Modrak (Technical Expert)

I. Scope and Application

This document describes procedures for measuring and recording wind speed and direction using portable hand-held field instrumentation. This SOP is designed as a supplement to policies and procedures outlined in the ARCADIS Employee Field Health and Safety Handbook and the site-specific Health and Safety Plans.

Note that this SOP does not cover deployment and/or operation of temporary or permanent meteorological stations.

II. Personnel Qualifications

No special training in meteorology is required to implement these procedures. This SOP assumes that ARCADIS field personnel will be familiar with the specific operating requirements of the respective equipment as provided by the manufacturer and be familiar with the applicable site Health and Safety Plan.

III. Equipment List

The following list of materials and devices are appropriate (but not all inclusive) for recording wind speed and direction:

- Portable anemometer (Dwyer, Brunton, other)
- Spare batteries
- Site map with north arrow
- Compass (with appropriate correction for local magnetic variation)
- Wind sock or wind vane
- Field book

IV. Cautions

- Local features such as buildings, trees or other fixed or temporary objects can interfere with the accurate measurement of wind speed and direction. When possible, wind measurements should be obtained at a location located a horizontal down-wind distance that is ten times the height of up-wind obstructions. For example, if taking a reading down-wind of a building 30 feet

tall, you should attempt to obtain the reading at least 300 feet down-wind of the building.

V. Health and Safety Considerations

- Refer to the project Health and Safety Plan. Generalized procedures can be found in the ARCADIS Employee Field Health and Safety Handbook.

VI. Procedure

Hold the instrument at eye level and face directly into the wind for at least one minute. Note the speed at 10-second intervals (6 readings) and average over the 1-minute period. Also note the peak gust. The wind direction is defined as the direction the wind is coming from. In order to establish the wind direction, face directly into the wind and record the compass direction. Alternatively, deploy a wind sock or wind vane and orient your compass by facing toward the larger open end of the wind sock or down the length of the wind vane. A wind sock is a conical textile tube designed to indicate wind direction and relative wind speed. Wind socks typically are used at airports and at chemical plants where there is risk of gaseous leakage. They are sometimes located on top of buildings with helipads (hospitals, industrial facilities, etc.) and alongside highways at windy locations. Wind direction is the opposite of the direction in which the wind sock is pointing (note that wind directions are conventionally specified as being the compass point from which the wind originates; so a windsock pointing due north indicates a southerly wind). Wind speed is indicated by the wind sock's angle relative to the mounting pole; in low winds, the windsock droops; in high winds it flies horizontally

VII. Waste Management

Not applicable to this SOP.

VIII. Data Recording and Management

Record readings in the field log book. In addition to taking readings at the site, wind observations from nearby airports can be used to supplement site specific data. Airport observations may or may not be representative of site-specific conditions depending on the relative distance from the site to the airport, terrain, buildings and other site features. Contact the meteorology sub discipline for an evaluation of nearby wind observing stations.

IX. Quality Assurance

Not required for this SOP.

X. References

No references

ARCADIS Employee Field Health and Safety Handbook. May 2008.

B11. Method 2D: Measurement of Gas Volume Flow Rates in Small Pipes and Ducts

Method 2D—Measurement of Gas Volume Flow Rates in Small Pipes and Ducts

Note: This method does not include all of the specifications (*e.g.*, equipment and supplies) and procedures (e.g., sampling) essential to its performance. Some material is incorporated by reference from other methods in this part. Therefore, to obtain reliable results, persons using this method should also have a thorough knowledge of at least the following additional test methods: Method 1, Method 2, and Method 2A.

1.0 Scope and Application

1.1 This method is applicable for the determination of the volumetric flow rates of gas streams in small pipes and ducts. It can be applied to intermittent or variable gas flows only with particular caution.

1.2 Data Quality Objectives. Adherence to the requirements of this method will enhance the quality of the data obtained from air pollutant sampling methods.

2.0 Summary of Method

2.1 All the gas flow in the pipe or duct is directed through a rotameter, orifice plate or similar device to measure flow rate or pressure drop. The device has been previously calibrated in a manner that insures its proper calibration for the gas being measured. Absolute temperature and pressure measurements are made to allow correction of volumetric flow rates to standard conditions.

3.0 Definitions[Reserved]

4.0 Interferences[Reserved]

5.0 Safety

5.1 This method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to performing this test method.

6.0 Equipment and Supplies

Specifications for the apparatus are given below. Any other apparatus that has been demonstrated (subject to approval of the Administrator) to be capable of meeting the specifications will be considered acceptable.

6.1 Gas Metering Rate or Flow Element Device. A rotameter, orifice plate, or other volume rate or pressure drop measuring device capable of measuring the stack flow rate to within ±5 percent. The metering device shall be equipped with a temperature gauge accurate to within ±2 percent of the minimum absolute stack temperature and a pressure gauge (accurate to within ±5 mm Hg). The capacity of the metering device shall be sufficient for the expected maximum and minimum flow rates at the stack gas conditions. The magnitude and variability of stack gas flow rate,

molecular weight, temperature, pressure, dewpoint, and corrosive characteristics, and pipe or duct size are factors to consider in choosing a suitable metering device.

6.2 Barometer. Same as Method 2, Section 6.5.

6.3 Stopwatch. Capable of measurement to within 1 second.

7.0 Reagents and Standards[Reserved]

8.0 Sample Collection and Analysis

8.1 Installation and Leak Check. Same as Method 2A, Sections 8.1 and 8.2, respectively.

8.2 Volume Rate Measurement.

8.2.1 Continuous, Steady Flow. At least once an hour, record the metering device flow rate or pressure drop reading, and the metering device temperature and pressure. Make a minimum of 12 equally spaced readings of each parameter during the test period. Record the barometric pressure at the beginning and end of the test period. Record the data on a table similar to that shown in Figure 2D–1.

8.2.2 Noncontinuous and Nonsteady Flow. Use volume rate devices with particular caution. Calibration will be affected by variation in stack gas temperature, pressure and molecular weight. Use the procedure in Section 8.2.1 with the addition of the following: Record all the metering device parameters on a time interval frequency sufficient to adequately profile each process cyclical or noncontinuous event. A multichannel continuous recorder may be used.

9.0 Quality Control

Section	Quality control measure	Effect
10.0	Sampling equipment calibration	Ensure accurate measurement of stack gas flow rate or sample volume.

10.0 Calibration and Standardization

Same as Method 2A, Section 10.0, with the following exception:

10.1 Gas Metering Device. Same as Method 2A, Section 10.1, except calibrate the metering device with the principle stack gas to be measured (examples: air, nitrogen) against a standard reference meter. A calibrated dry gas meter is an acceptable reference meter. Ideally, calibrate the metering device in the field with the actual gas to be metered. For metering devices that have a volume rate readout, calculate the test metering device calibration coefficient, Y_m, for each run shown in Equation 2D–2 Section 12.3.

10.2 For metering devices that do not have a volume rate readout, refer to the manufacturer's instructions to calculate the V_{m2}corresponding to each V_r.

10.3 Temperature Gauge. Use the procedure and specifications in Method 2A, Section 10.2. Perform the calibration at a temperature that approximates field test conditions.

10.4 Barometer. Calibrate the barometer to be used in the field test with a mercury barometer prior to the field test.

11.0 Analytical Procedure.

Sample collection and analysis are concurrent for this method (see Section 8.0).

12.0 Data Analysis and Calculations

12.1 Nomenclature.

P_{bar}=Barometric pressure, mm Hg (in. Hg).

P_m=Test meter average static pressure, mm Hg (in. Hg).

Q_r=Reference meter volume flow rate reading, m^3 /min (ft^3 /min).

Q_m=Test meter volume flow rate reading, m^3 /min (ft^3 /min).

T_r=Absolute reference meter average temperature, °K (°R).

T_m=Absolute test meter average temperature, °K (°R).

K_l=0.3855 °K/mm Hg for metric units,=17.65 °R/in. Hg for English units.

12.2 Gas Flow Rate.

$$Q_s = K_1 Y_m Q_m \frac{(P_{bar} + P_m)}{T_m} \qquad Eq.\ 2D\text{-}1$$

12.3 Test Meter Device Calibration Coefficient. Calculation for testing metering device calibration coefficient, Y_m.

$$Y_m = \frac{Q_r T_r P_{bar}}{Q_m T_m (P_{bar} + P_m)} \qquad Eq.\ 2D\text{-}2$$

13.0 Method Performance[Reserved]

14.0 Pollution Prevention[Reserved]

15.0 Waste Management[Reserved]

16.0 References

1. Spink, L.K. Principles and Practice of Flowmeter Engineering. The Foxboro Company. Foxboro, MA. 1967.

2. Benedict, R.P. Fundamentals of Temperature, Pressure, and Flow Measurements. John Wiley & Sons, Inc. New York, NY. 1969.

3. Orifice Metering of Natural Gas. American Gas Association. Arlington, VA. Report No. 3. March 1978. 88 pp.

17.0 Tables, Diagrams, Flowcharts, and Validation Data

Plant_____
Date_____
Run No._____
Sample location_____

Barometric pressure (mm Hg):

Start_____
Finish_____
Operators_____
Metering device No._____
Calibration coefficient_____
Calibration gas_____
Date to recalibrate_____

Time	Flow rate reading	Static Pressure [mm Hg (in. Hg)]	Temperature	
			°C (°F)	°K (°R)
Average				

Figure 2D–1. Volume Flow Rate Measurement Data

B12: Colorimetric Field Screening for Hydrogen Fluoride

B12.a. Sensidyne Gas Detector Tube 156S Hydrogen Fluoride

HYDROGEN FLUORIDE - Tube: 156S

HYDROGEN FLUORIDE - Range: 0.17-30 ppm Gas Detector Tube

Measured Gas: HYDROGEN FLUORIDE

Tube Number: 156S

Range: 0.17-30 ppm

Tubes Per Box: 10 tubes

Tube Type: Standard Tube

Uses Conversion Chart: No

Operating Range: Normal Operating Range

Download Datasheet

Buy HYDROGEN FLUORIDE - Tube: 156S Online

Note: Some detector tube applications are achieved by applying a correction factor to an existing detector tube to correct the reading for the new substance. Often, these correction factors or conversion charts are provided in the detector tube's instruction sheet. If your desired correction information is not provided in the tube instruction sheet, please contact our Customer Support group for assistance.

HYDROGEN FLUORIDE - Tube: 156S Links

- Detector Tube Pumps
- Specialty Kits and Accessories
- HazMat-III Kit Brochure
- Detector Tubes
- WATER VAPOUR - Tube: 177UR2
- METHYL ISOTIOCYANATE (MITC) - Tube: 245UL

Connect with us.

B12.b. Sensidyne Model AP-20S Gas Detection Pump Instruction Manual

SENSIDYNE®

Model AP-20S
Gas Detection Pump
Instruction Manual

Made in Japan for Sensidyne by Komyo Rikagaku Kogyo K.K.

Sensidyne Document No. 360-0027-01 Revision A

Table of Contents

FOREWORD

Thank you for purchasing the Model AP-20S sampling pump. The Model AP-20S pump is designed specifically for use with Kitagawa detector tubes. This system with the available Sensidyne/Kitagawa detector tubes can detect the presence of more than 300 airborne gases and vapors.

FOR SAFE AND CORRECT USE

- Read carefully both this instruction manual and the instruction sheets for the individual detector tubes prior to use of this product.
- Ensure that this instruction manual is stored in a convenient location for easy reference at all times.
- If you have any questions regarding this manual, please contact your local distributor or manufacturer representative.

The following symbols are used in this manual

CAUTION: Failure to observe this instruction can result in possible personal injury or damage to property.

NOTE: Indicates instruction or advice for the correct use of the product, to prevent problems with the product.

- With a detector tube inserted and the handle drawn back, the pump cylinder is under a high vacuum. If the handle lock is released under vacuum conditions, it will pull back suddenly. Holding the pump by the extended shaft can lead to injury. Always hold the pump by the cylinder, never by the shaft.
- Broken glass tube tips can fall from the tip cutter or storage area when using the pump. To prevent glass contamination in restricted area (e.g., food processing plants) use the optional Deluxe Tip Cutter (PNº 7013601).
- Normal use of detector tubes requires the handling of broken glass tubes. Safety glasses and protective gloves are recommended.
- Avoid skin and eye contact with the internal chemical reagents.
- If the reagent is completely discolored (i.e., the detector tube is over- ranged) after measuring a high concentration toxic gas (e.g., a process measurement), the possibility exists for harmful gas residue inside the cylinder. This gas will exhaust from the back of the cylinder when the handle is pulled out for the next pump stroke. Whenever the tube has fully discolored, purge the air inside the cylinder by pulling and pushing the handle several times in a well-ventilated area.

NOTES

- If the proper detector tube for a particular application is not chosen, correct readings cannot be obtained. Choose detector tubes carefully using the tube selection guide and pay strict attention to chemical names and measuring ranges.
- When gases other than the target gas are also suspected, refer to the tube instructions for a list of known interfering compounds and their relative affect on the reading. Consult the tube selection guide or handbook for tubes that can monitor those gases.
- A detector tube is designed for a single use; do not re-use detector tubes.
- A detector tube should be used immediately after breaking the ends. Detector tubes exposed to the air for a long time after breaking the ends will give erroneous readings, and may not respond to the target gas at all.
- Read the concentration immediately after completion of measurement. If not read immediately, the stain may lengthen or fade, which can lead to erroneous readings.
- A leaking pump will produce low readings. Always check the pump for leakage before use in accordance with section “CHECKING PRIOR TO USE”.
- The temperature range for use of detector tubes in general is 0 to 40 degrees C. When using detector tubes at temperatures outside of the above range, refer to the section “MEASUREMENT UNDER SPECIAL CONDITIONS.”
- Do not drop or strike the pump. If the cylinder is dented, it will impede the handle operation and possibly cause leakage.
- Should the pump be disassembled, hand tighten only on re-assembly. Over-tightening can damage threads.
- Clean the pump only with a dry paper towel. Do not use water or solvents.
- Do not store the pump in the areas of high temperature or high humidity. Do not store with the handle extended, as the pump shaft is susceptible to bending under stress.
- It is recommended that service repair be done only by authorized service centers. Any service or repair must be followed by a leak check prior to field use.
- Note that the AP-20S pump is a vacuum pump only, and it cannot be used for specialized detector tubes that require sample entry by pressure (Oxygen, Hydrogen, Propane, etc.)

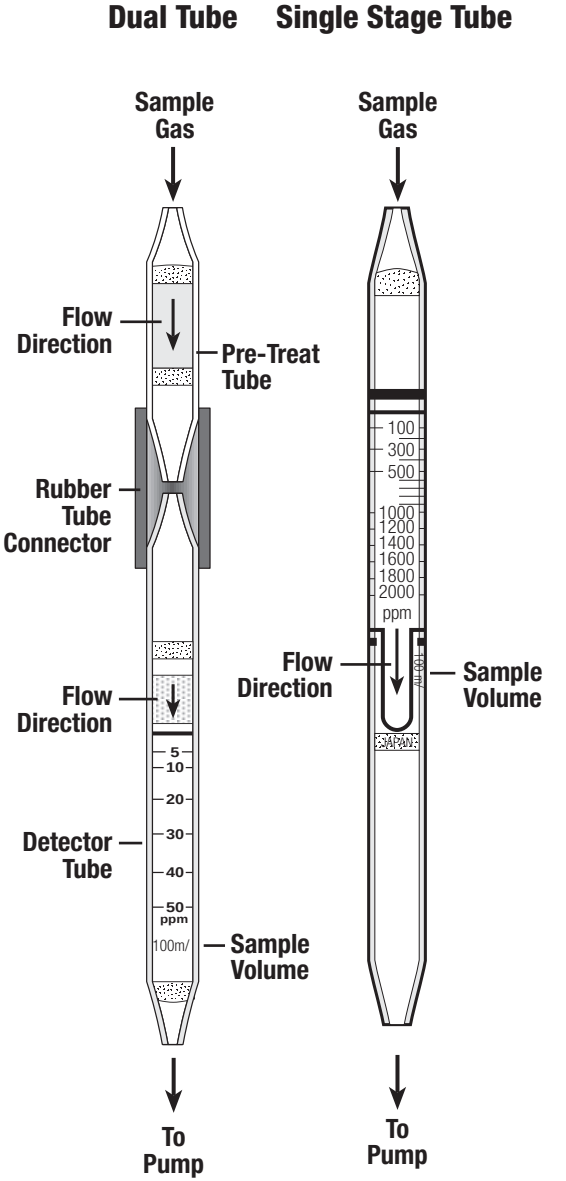
DISPOSAL OF DETECTOR TUBES

A detector tube contains a chemical reagent which reacts with the target gas. The chemical reagents used vary among different types of detector tubes, and may include substances regulated by laws for proper disposal. When discarding used detector tubes, dispose of them in accordance with local disposal regulations. For further information contact your local distributor or the manufacturer’s head office or branches.

AP-20S Pump Accessories

AP-20S Pump Components

DETECTOR TUBE COMPONENTS

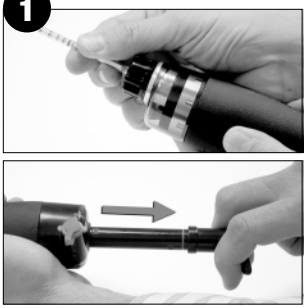


Performing The Leak Test

NOTE

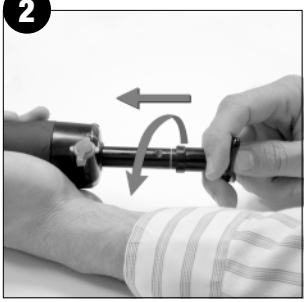
A leaking aspirating pump may cause lower readings or no response at all. **Always perform a leak check before using the pump**.

1



Insert a **sealed, unbroken detector tube** into the rubber tube connector. Align the red lines on the pump and shaft handle, and pull the handle to full stroke locked position.

2

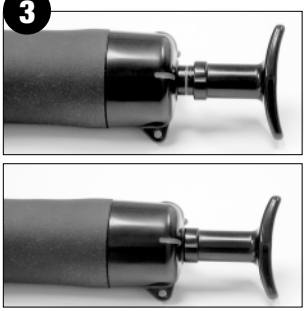


Wait one minute. Unlock the handle by turning it 1/4 turn (90°). Hold the cylinder and handle **securely** while allowing the handle to **slowly** return to its initial position. The pump passes the leak test If the handle returns completely to its original position. If the red line on the pump shaft is visible, the pump has failed.

CAUTION

When the lock is released under full vacuum the handle tends to snap back quickly

3



If the pump fails the leak test, the following are possible causes:

A) A loose inlet connector holder.
B) Cracks and deterioration of the rubber tube connector.
C) Deterioration of the grease.

To correct a leaking pump, consult the **MAINTENANCE** section.

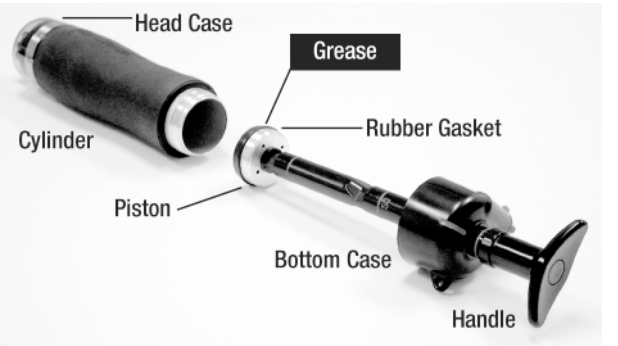
MAINTENANCE

• Lubricating The Pump

1. Pull the handle part way and turn the bottom case counterclockwise to remove it.

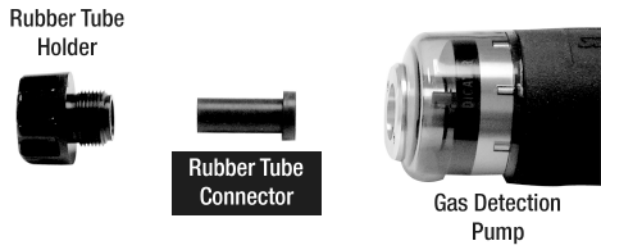
2. Pull the piston out from the cylinder.

3. Wipe off the old grease and dirt from the piston and inside the cylinder using a clean paper towel. Apply a thin coat of grease to the rubber gasket of the piston. When wiping off the old grease, be careful not to scratch the inside walls of the cylinder. Reassemble pump.



• Replacing The Rubber Tube Connector

If the rubber tube connector appears cracked or deteriorated, remove the connector holder and replace it with new one.



OPERATING PROCEDURE

READ THESE NOTES PRIOR TO USING PUMP

- The operating procedure varies from one detector tube to another. Before proceeding, read carefully the individual instruction sheets provided in each box.
- Some detector tubes require temperature and/or humidity correction using tables provided in the instruction sheets. Be sure that the tube temperature has reached equilibrium with the sample area before drawing the sample.
- When using detector tubes at pressure other than normal atmospheric pressure, correction of the reading is necessary. Refer to the section "MEASUREMENT AND OPTIONS UNDER SPECIAL CONDITIONS."
- To read the tube scale directly, it is necessary that the pressure of the sample gas is equal to that of the pump.
- When sampling high-pressure systems, first collect the sample in a gas sampling bag (non-adsorbent material), then use the pump to draw the sample from the bag.

• Taking a Measurement

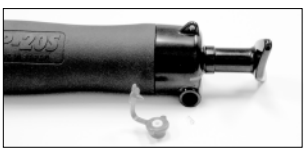
NOTE

Always perform a leak check on the pump (page 7) before taking a sample.

1

Cut both ends of the detector tube. Insert the tip of a fresh gas detector tube into the tip cutter. Score the tip by rotating the tube one revolution. Pull the tube toward you at an angle to break the tip.

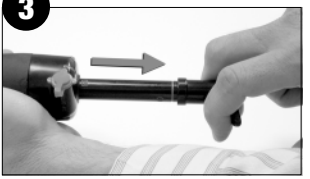
Repeat this for the tip at the other end of the tube.



(The glass tip can be disposed by removing the tip cutter cap.)

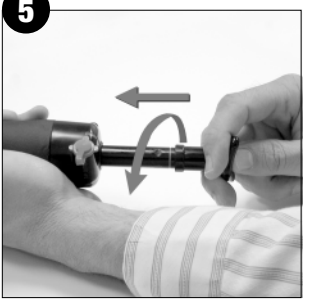
OPERATING PROCEDURE

Insert detector tube. Insert the gas detector tube into the rubber tube connector in the pump. Make sure the tube's arrow is pointing toward the pump.



Pull the handle. Align the two red marks on the pump and shaft handle. Pull the pump handle to its full 100cc locking position for a full stroke, or to the 50cc locking position for a half stroke.

Draw the sample gas. Take a sample for the specified time at the desired sampling point as shown in the tube instructions. The sample is complete when the flow finish indicator appears.



Return the handle. When the sample is complete, turn the handle 1/4 turn (90°) to unlock the handle. Confirm that the handle remains extended. (If the handle returns part way, the sample is incomplete, causing a low reading). If the detector tube requires more than one stroke, push back the handle and repeat the operation, as many times as required.

Read the concentration. After the prescribed sample volume has been drawn, remove the tube from the pump. Read the concentration and perform any temperature corrections as described on page 12 and in the tube instructions.

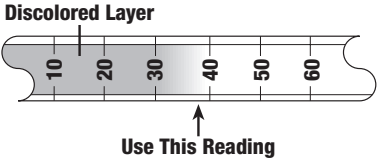
Reading The Gas Concentration

For direct-reading tubes, read the gas concentration from the printed scale at the maximum end of the stain.

Two special cases are described below: Faint Discoloration and a Slanted Stain.

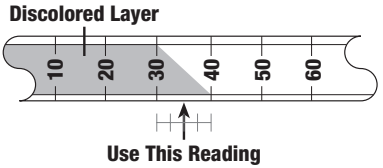
• Faint Discoloration (Feathering)

For a faintly discolored (feathered) stain read the gas concentration at the maximum end of the stain.



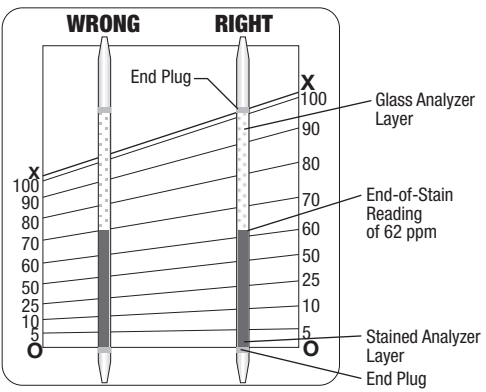
• Slanted Stain

For a slanted stain read the gas concentration at the middle of the slanted layer.



• Using A Conversion Chart

Align the zero end of the detecting reagent (inlet side of the tube) with the O - O line on the concentration chart. Align the other end of the same layer (exit side or pump side of the tube) with the X - X line respectively. Read the gas concentration at the maximum end of the stain against the scale on the card. If the end is slanted, read at the middle point of the slanted stain.



TEMPERATURE CORRECTION

The temperature of concern is that of the detector tube (usually the temperature of the sample gas).

• USING A CORRECTION TABLE

[Example] When the tube reading is 550 ppm at 25°C the true concentration is found by interpolating between the concentrations listed for 20° and 30°. In this example, the corrected value is 560 ppm.

Temperature Correction (at 20°C)					
Scale Reading (ppm)	True Concentration of Carbon Monoxide (ppm)				
	0°C	10°C	20°C	30°C	40°C
1000	870	930	1000	1030	1060
900	780	840	900	930	960
800	690	750	800	830	860
700	610	660	700	720	740
600	520	560	600	620	620
500	430	470	500	520	540
400	350	370	400	410	430
300	260	280	300	310	320
200	180	190	200	210	220
100	90	100	100	100	110

Scale readings °C	20°C	25°C	30°C
700	700	710	720
600	600	610	620
550	(550)	**(560)**	(570)
500	500	510	520
400	400	405	410

• USING A CORRECTION COEFFICIENT

[Example] When the detector tube reading is 0.4 mg/ℓ at 23°C, the true concentration of water vapour is 0.36 mg/ℓ by the following calculation: 0.4 mg/ℓ X 0.90 = 0.36 mg/ℓ

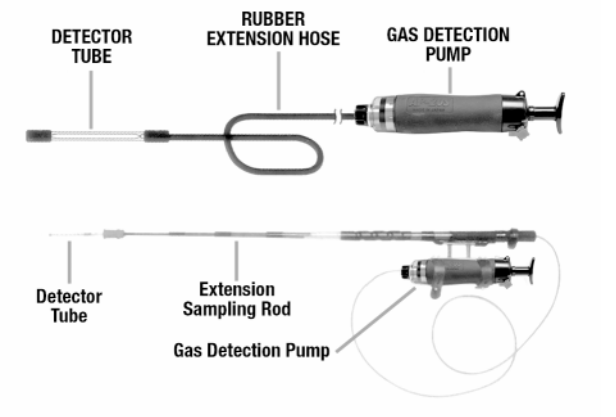
Temp. (°C)	0	1	2	3	4	5	6	7	8	9
0	1.85	1.81	1.77	1.72	1.68	1.63	1.59	1.54	1.49	1.45
10	1.40	1.36	1.31	1.27	1.23	1.19	1.15	1.11	1.07	1.03
20	1.00	0.96	0.93	0.90	0.87	0.84	0.81	0.78	0.76	0.73
30	0.71	0.68	0.66	0.64	0.62	0.60	0.58	0.56	0.55	0.53
40	0.51	—	—	—	—	—	—	—	—	—

Temp. (°C)	0	1	2	3	4
0	1.85	1.81	1.77	1.72	1.68
10	1.40	1.36	1.31	1.27	1.23
20	1.00	0.96	0.93	**0.90**	0.87
30	0.71	0.68	0.66	0.64	0.62

Measurement under Special conditions

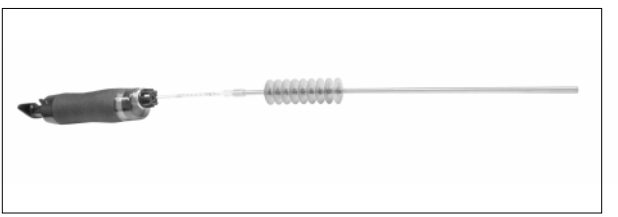
• Remote Measurement

A rubber extension hose (shown below) is used for remote detection of potentially harmful gases prior to entering a confined space such as a manhole or tank. The extension hose is placed between the detector tube and the pump to eliminate the need for purging. The rubber extension hose is available in lengths of 5 or 10 meters.



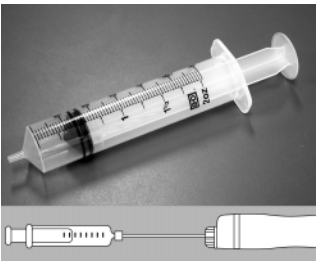
• High Temperature Gas Measurement

The allowable temperature range for detector tubes is generally, 0° to 40°C. When measuring gases at temperatures outside of 0° to 40° C, collect a volume of gas into a container, transport it to a moderate area (i.e., indoors) and allow it to equilibrate. Then draw the sample from the container. Care must be taken to choose a container of a material that is compatible with the target gas. (e.g., A glass syringe of 100cc or 200cc or a Tedlar bag of 1 to 2 liters is a suitable container). When flue gas or other high temperature gas is sampled, use the Hot Air Probe.



Measurement under Special conditions

• High Concentration Gas Measurement



High concentration gas exceeding the measuring range of the detector tube may be sampled as follows. Collect a volume of sample gas into a glass syringe and dilute with fresh air. (See photograph). The tube reading is then multiplied by the ratio of dilution to determine the actual concentration. Example: Draw 50cc of sample gas into a 100cc syringe. Complete the syringe draw with fresh air. Take a reading and multiply by 2.

• Atmospheres With Non-ambient Pressure

If 100cc of gas is collected at a pressure that is two times atmospheric pressure, it is equivalent to 200cc of gas collected at normal atmospheric pressure. When measuring at pressures other than normal atmospheric pressure, a pressure correction is required.

A true concentration can be obtained by the following equation. However, if the tube's concentration scale is nonlinear, a correction error is produced. Therefore it is recommended to collect the sample in a gas sampling bag, then measure it at normal atmospheric pressure for more accurate readings.

When collecting gas in a high pressure atmosphere, please note that the bag can be ruptured by the expansion of the sample gas.

Corrected value = Reading value on detector tube x 760 mmHg/ Atmospheric pressure in the measuring place [mmHg]

Options & accessories

Hazardous Material Detection Kit

The Hazmat III Kit (PNº 7013627) is a portable hazardous material detection kit that is lightweight, rugged, and capable of on-the-spot detection of numerous airborne contaminants. The kit utilizes a unique two-step approach and a special color chart to determine nearly 70 compounds in as little as 2–3 minutes. The kit requires no electrical power or user calibration and comes with a hard-shell, corrosion-resistant polyethylene case.

One-Hand Adapter

The one-hand adapter for the Sensidyne Model AP-20S Pump is ideal for one hand sampling from a ladder or into hard-to-reach places. With the adapter installed and a tube inserted, the pump handle can be drawn and locked without actually taking a sample. The pump can then be extended into the sampling area and activated with one hand.

Extension Hose

An extension hose of either 5 meters (PNº 830-1001-01) or 10 meters (PNº 830-1002-01) in length is available for use in confined space entry, as well as a rigid telescoping extension probe with up to 10 working feet of length (PNº 830-1003-01). The design of the tube holder at the free end of the hose permits a gas-tight fitting. Since the detector tube is located at the sampling end of the hose, there is no need to allow for the volume of air in the hose line.

Hot Probe

The Hot Probe (PNº 7013602) allows sampling of gases at elevated temperatures (up to 250°C [482°F]) for applications such as auto exhaust or stack emissions testing. The Hot Probe rapidly cools the gas before it enters the detector tube.

Compressed Breathing Air Analysis Kit

The Compressed Breathing Air (CBA) Analysis Kit (PNº 7015406) allows anyone to simply, quickly, and quantitatively measure the quality of their compressed breathing air. Easy to use, the CBA Kit is an accurate and precise method for detecting carbon monoxide (PNº 600SP), carbon dioxide (PNº 601SP), oil mist (PNº 602SP), oxygen (PNº 604SP), and water vapor (PNº 6003SP) *(specific tubes not included)*. The CBA Kit measures all four of the common contaminants in breathing air, plus oxygen deficiency.

Tube Tip Breaker/Cutter

The Tube Tip Breaker/Cutter (PNº 7013601) is a convenient container for cutting and breaking detector tubes.

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